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AMERICAN WATER WORKS ASSOCIATION

Shasta Dam—Power, Storage, Flood Control

AMERICAN WATER WORKS ASSOCIATION

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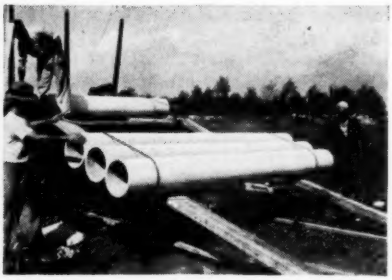

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A.W.W.A. 1949 ANNUAL CONFERENCE

Stevens Hotel, Chicago **May 30—June 3**

A legal holiday on May 30 will not affect existing plans.

Reservations must be on standard forms and cleared through the A.W.W.A. office.

April

1–3—Arizona Section at Hassayampa Hotel, Prescott, Ariz. Secretary: Mrs Helen Rotthaus, Sanitary Eng. Div., Arizona State Dept. of Health, Phoenix, Ariz. Hotel reservations through the Prescott Chamber of Commerce.

8–9—Montana Section at Johnson Hotel, Great Falls, Mont. Secretary: C. W. Brinck, Montana State Board of Health, Helena, Mont.

20–22—Indiana Section at Lincoln Hotel, Indianapolis. Secretary: C. H. Bechert, Director, Div. of Water Resources, Indiana Dept. of Conservation, 445 N. Pennsylvania Ave., Indianapolis 4, Ind.

21–22—Kansas Section at Bisonte Hotel, Hutchinson, Kan. Secretary: Major C. Hagar, Supt., Water Dept., Lawrence, Kan.

21–22—Nebraska Section at Cornhusker Hotel, Lincoln, Neb. Secretary: John W. Cramer, Partner, Fulton & Cramer, 922 Trust Bldg., Lincoln 8, Neb.

24–27—Canadian Section at Chateau Frontenac, Quebec City, Que. Secretary: Dr. A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 2, Ont.

28–29—New York Section at Mark Twain Hotel, Elmira, N.Y. Secretary: R. K. Blanchard, Vice-President, Neptune Meter Co., 50 W. 50th St., New York.

29—California Section regional spring meeting at Bakersfield, Calif. Secretary: H. C. Medbery, Engr. of Water Purification, San Francisco Water Dept., Millbrae, Calif.

May

12–14—Pacific Northwest Section meeting.

June

23—New Jersey Section outing.

Journal

AMERICAN WATER WORKS ASSOCIATION

March 1949

Vol. 41 • No. 3

Contents

Proposed Water Rate Schedule .... MICHIGAN SECTION COMMITTEE REPORT 209

The Causes and Prevention of Water Losses .... HOMER E. BECKWITH 222

Measuring Pump Performance During Operation .... N. C. EBAUGH 227

Maintenance of Electrical Equipment .... W. J. SEIBERT 237

Effect of Water Quality on Ornamental Plants .... HAROLD E. PEARSON 242

The Value of Consumer Complaints .... LAURENCE L. CAMY 249

Ground Water in Wyoming .... DONALD A. WARNER 253

Transportation Tax Exemption 256

Report of the Audit of Association Funds 257

A.W.W.A. Pension System 263

Report of the Committee on Water Works Practice 270

Report of the Committee on Water Works Administration 277

Report of the Editor 279

The George Warren Fuller Award 284

Tentative Standard Specifications for Filtering Material 289

Departments

Cover Story .... *text p.* 241

Officers & Directors ii

Division & Section Officers iv

Coming Meetings viii

Percolation & Runoff 1

Correspondence 22

Membership Changes 28

Condensation 48

Service Lines 62

Section Meeting Reports 66

List of Advertisers 76

Index of Advertisers' Products 78

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Journal

AMERICAN WATER WORKS ASSOCIATION

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Proposed Water Rate Schedule

Michigan Section Committee Report

A report presented on Sept. 23, 1948, at the Michigan Section Meeting, Flint, Mich., by the Michigan Section's Committee on Water Rates, composed of Louis E. Ayres, Chairman; P. H. Beauvais; Earl E. Norman; Hal F. Smith; and Frank R. Theroux.

THE Michigan Section's Committee on Water Rates was instructed "to formulate a workable pattern or formula by which water works personnel may be guided in arriving at the formulation of water rates which are based on sound engineering principles."

Obviously, this is a large order, because there is no subject in the water works field on which there has been more controversy over the years, or where there has been a wider divergence in the application of theories, as exemplified by the rate structures extant across the land.

A.W.W.A. Schedule

Over 25 years ago, the A.W.W.A. adopted "a standard *form* of rate schedule" (1), but the rules covering its application have never been written. The form provides for a "service" charge and a consumption charge in "three slides," or possibly with "a fourth and lower rate for large manufacturers, if deemed desirable."

Strangely enough, the *quantity* of water to be delivered in each slide was fixed; only the price per unit was left to be determined, but with the qualification "that the ratio between the first and third rate should be limited to about 2 to 1" and "the amount of slide between the first and fourth rates should not exceed the ratio of 3 to 1." No basis for fixing the unit prices of the steps is suggested.

The principal difficulty in applying the A.W.W.A. rate schedule has been the determination of the division of income between the service charge and the consumption or commodity charge. The instructions in *Water Works Practice* (1) favored a "ready-to-serve" cost basis in which the service charge included most maintenance costs and "a certain portion of operating expenses, as well as all interest, taxes and depreciation"; but, after having taken this position, because it was the "more general method" in practice, the editors retracted with the statement that

sometimes "an analysis of cost . . . carried out in this way will result in putting a considerable proportion of the total cost on the service charges. *Theory should not be carried to extremes,* and regardless of calculation, it is best to limit the service charges in all cases to reasonable amounts, not greatly exceeding those actually adopted in other cases. *The consumption charges should, in all cases, carry the major part* of the entire cost of service." *

In 1937 C. C. Ludwig (2) attempted to apply the A.W.W.A. rate schedule to a typical small water works. He made an analysis of costs, "both capital and current," and presented "a breakdown according to the three theoretical factors: [1] readiness to serve customers, [2] readiness to fight fires and [3] provision for water." Although the figures presented were a sample analysis and "would be modified to take account of local factors," the breakdown indicates the author's general theories:

1. All production costs—fixed, operation and maintenance—are chargeable to "providing water" and are recovered through the consumption or commodity price; and nothing else is included in the commodity price except a small arbitrary portion of "overhead" (say 25 per cent).
2. All costs arising out of distribution mains are divided between the "service" charge and the "fire" charge on something like a 70:30 basis in a small town.
3. All storage facilities are divided about equally between "service" and "fire."
4. All hydrant costs are chargeable to "fire"; and all "service and meter" costs and "customer accounting, billing and meter reading" are chargeable to "service."
5. As to general overhead, 50 per cent is charged to "service," 25 to "fire" and 25 to "providing water," as above. This happens to be the same division as for the "fixed charges."

The result of such an analysis, in the particular water works, apportions the total annual costs as follows: readiness to serve customers, 35.1 per cent; readiness to serve fires, 16.65; and providing water, 48.25. These allocations of costs are, obviously, one man's judgment without the support of any expressed defense or logic. In effect this writer believes that the total costs should be divided about 50–50 between "commodity" and "readiness-to-serve" charges.

Just why the "commodity" charge should be limited to production costs *only* and carry *no part* of distribution costs is not obvious; nor is it clear why none of the production expense is charged to "readiness-to-serve," either "customer" or "fire."

Service Charges

Examining the literature on the subject of water rates over the last 30 years, one finds a wide range of assumptions in the writings of many engineers. Probably the minimum service charge, and hence the largest commodity charge, was suggested in 1922 by Allen Hazen (3). He limited "service cost" to "costs of the connections and meters and bookkeeping and collecting" plus "some small part" of the cost of distribution; and the "cost of water" would include *all* production costs plus "a large part" of the cost of distribution.

* Committee's italics.

Another principle that has frequently been applied is to charge *all fixed charges* to "readiness-to-serve" and all operating costs to the cost of water. Still other rate schedules include all fixed charges and varying proportions of operating costs in the service charge. Extreme examples have included in the service charge all fixed charges and all operating and maintenance expense, except those costs that actually vary with the amount of water produced.

The committee's attention has been called to one such extreme allocation of expense in a sewerage system:

Item	Cost	*per cent*
Costs due to capacity	$ 71,115	66.8
Costs due to commodity	4,442	4.2
Costs due to users	27,841	26.2
Costs due to public	2,960	2.8
Total	$106,358	100.0

The "costs due to capacity and to the public," comprising 69.6 per cent of the total, "may logically be distributed in accordance with use and opportunity for use," according to a tentative draft of the proposed Federation of Sewage Works Assns. manual on accounting. And "the accepted criterion for this *opportunity* in water works practice is the size of the service connection including the water meter." In addition, "the costs which are due to the users of the system (26.2 per cent) are commonly distributed equally among these users." In other words, the sum of 69.6 plus 26.2, or 95.8 per cent of the *total costs* of service, is allocated to users on bases independent of the amount of use, leaving only 4.2 per cent of the "costs which are due to the commodity itself . . . distributed in accordance with actual metered usage." In this example, the commodity cost was limited to "pumping station power" alone. Every other expense was considered a standby cost in a plant standing ready to serve, with all employees at attention, set to operate when the first drop of sewage is pumped.

Actually no rate schedule in which 95 per cent of the cost is collected through a service charge would be acceptable. In the sewerage system cited, there was no service charge, as such, proposed, but the cost allocations were used to determine the unit rates in an *eight-step* schedule in which the ratio of unit rates was $9\frac{1}{2}:1$.

Such a basis is the extreme position to which one is inevitably driven in any attempt to apply the theory of a "readiness-to-serve" charge. There is no place along the line at which one may stop logically. The charge cannot be applied except arbitrarily or on the basis of judgment and precedent elsewhere.

Having determined, on some basis, a total amount of service charge, it has been the usual practice to distribute this total to customers on the basis of the capacity ratio of the meters.

Water Works Practice states: "The capacity of meters may be rated arbitrarily by their areas, which is not a very satisfactory arrangement, or by their relative carrying capacities, either at 25 pounds loss of head . . . or at an ordinary working basis such as 5 pounds. . . . The relative capacities will be the same in either case" but "a consumer situated in a high part of the system where the pressure is low cannot obtain as much water as another, with the same size meter, in a higher pressure district. Pressure should theoretically be a factor in the makeup of the service charges. It is obvious, however, that such a procedure is practically impossible in a rate schedule."

The manual concludes that "the apportionment of service charges among the various users is believed to be most equitable, fair and just, when based upon the relative capacities of the meters supplying the service." Having come to this conclusion, the relative capacities of a 6-in. and a ⅝-in. meter are presented in terms of ratios:

Basis	Capacity Ratio
Nominal pipe areas	92.16
Manufacturers' ratings	100
Former New Eng. Assn. Rate Com.	60
A.W.W.A. Meter Specifications	50
Lowest in table	30

Reviewing many existing rate schedules, as well as those advocated in recent issues of the JOURNAL, it would appear that meter capacity ratios frequently vary 100 per cent or more. Obviously, these variations materially affect the distribution of costs to the customers, particularly if a relatively large proportion of the expense is allocated to the "readiness-to-serve" charge. One may well be puzzled to decide what capacity ratio basis should be adopted; and it seems reasonable to conclude that the choice must be arbitrary.

Rate Schedule Slides

There are no suggestions in the A.W.W.A. rate schedule for methods of determining actual values, except that the ratio between the first and third steps is limited to "about 2 to 1" and the adopted steps when applied to the estimated sales will produce the requisite revenue. Generally, by cut-and-try methods and by reference to schedules in other cities, an end result is approximated. But there is no particular logic in the process of fixing unit charges for the several classes of customers.

After reviewing the literature on the subject, one is impressed with the fact that water rates are the result of individual judgment, arrived at without much explanation of method and defended by reference to the records of rates elsewhere.

Although three or four slides or steps have been recommended, current practice may use five to seven slides; and the more slides, the more difficult it would appear to be to formulate any basis or rule for their relationship.

Divergence From Current Practice

The foregoing comments, presenting but a brief review of the existing situation in connection with water rates, suggest an amazing confusion about the basis for their determination and a wide diversity not only in existing rates but in the schedules being currently proposed by leading water works engineers. In view of these facts, the committee, in trying to develop a formula, may appear to be attempting the impossible. But the committee has persisted in its efforts to comply with instructions, which were to "formulate a pattern . . . based on sound engineering principles." The members believe that they have succeeded in agreeing on some logical rules for rate making which may prove to be constructive, although it will take more discussion and the application of these rules to local data before final bases can be made acceptable for adoption.

The committee's conclusions, however, lead to modifications in certain established theories and practices in rate making, the propriety of which has been sustained by public utility

commissions, courts and general practice. It is therefore with some temerity that the committee proposes the major changes in rate-making methods discussed in this report.

Demand Charge

First, the committee is largely discarding the theory of the "readiness-to-serve" or "capacity" or "demand" charge. It is not *substantially* applicable to the water works field, except as a basis for fixing the "fire" charge, as the late Allen Hazen pointed out in 1922 (3). In discussing the "capacity charge," he said: "this term comes from the electric light business, and, in the electric light business, the capacity charge seems to be an item of vital interest. In the water works business, it is not nearly as important. Water takers have very regular habits, and the maximum drafts occur at well determined times; and within limits, they can be easily met by any properly equipped water works system."

Although rate theories in the electrical industry have been modified through the years, and "demand" charges based on demand meters apply now only to power and commercial users, in the water works field old theories persist and have been developed beyond the intent of the originators and to the detriment of the domestic customer.

Discussing the difference between electrical and water rates, even from the viewpoint of 30 years ago, Hazen (4) noted that "electricity must be generated and carried and distributed second for second to meet the requirements of the consumers . . . and peak loads in the electrical business are high with reference to main output . . . and also irregular. . . . The cost of furnishing and keeping the equipment ready for service to meet these peaks is a very important part of the whole cost of the electric service." But "with a water works system . . . the peak loads are much less marked. . . . The amount of storage required to cover all such peak loads . . . is relatively small; and the cost of furnishing the storage is hardly an appreciable element in the whole cost of supplying water." "Practically speaking, it makes no difference to the water works system whether an individual consumer draws 5 gal. in one minute or in ten minutes."

The theory of readiness-to-serve as discussed in *Water Works Practice* goes far beyond the earlier recommendations of the New England Water Works Assn. or those of Hazen. The N.E.W.W.A. limited the service charge to [1] fixed charges on the investment in service pipe and meters; [2] reading, billing and collecting; and [3] the cost of "unregistered water." The manual, however, suggests the inclusion in what it calls the "service charge," of all "ready-to-serve" costs —"interest, taxes, depreciation and a certain portion of operating expenses" and "*maintenance* on the pumping station, reservoirs, filter plant and distribution mains." Hazen [4] has said, however, that, when "interest and depreciation on the entire water works plant" are added to the service charge it "results in placing a heavy and unfair burden upon the smallest consumer." That is exactly what has happened to too many water rate schedules and it is still being proposed by well known water works advisers in recent issues of the JOURNAL and in other current water works literature. It seems to be an accepted obligation of the cus-

tomer with a ⅝-in. meter to pay the water department about $15.00 a year whether he uses water or not, "in order that fixed financial charges which are inexorable can be met safely and surely." And it is likely that this exaggeration of the service charge has resulted in its omission from a large proportion of schedules.

Water works plants never *stand* ready to serve; they are always serving. They have peaks, of course, which they must be able to meet—fire, sprinkling and the demands of hot weather, in the home, in places of business and in industry. These peaks require additional investment in pumping and other equipment, and in mains and storage. To the extent that such peaks can be assigned to fire, residential sprinkling and other demands, the additional costs, properly allocated, would be a justified readiness-to-serve charge. In fact, such an allocation appears to be the only basis for a fire charge. But outside of the fire charge there appears to be no method for equitably measuring and allocating to customers readiness-to-serve costs arising out of peak use of water.

Meter Capacity Ratio

Second, the committee discards the capacity ratio theory of meters as a means of distributing readiness-to-serve charges, for the reason that it does not, in the committee's opinion, afford a fair approximation to equity. Hazen (4) writes: "Ninety per cent more or less of all the consumers are supplied by meters and services of the same size. The fact that all of these services are of the same size is a matter of practical economy and convenience and does not represent equality of conditions among all these takers. To assess a considerable part of the whole cost upon the consumers in proportion to the size of meters would mean that the differences in conditions . . . would be ignored," and this "is not equitable."

As pointed out in *Water Works Practice,* the capacity of a meter depends upon the pressure area of the customer, and hence the permissible pressure loss through his meter. A ⅝-in. meter in a high-pressure area may have more "capacity" than a 1-in. meter in a low-pressure area. If pressures were uniform over an entire area and all meter sizes were so selected that the actual ratios of maximum demand to average use were uniform, then the application of the capacity ratio would give an equitable distribution of costs. But this is an ideal, never possible even to approximate. It would require as many meter sizes as there are different rates of demand.

If a maximum-demand meter were available to the water works industry as it is in the electrical field, there would be a means of distributing a demand charge; but the ordinary water meter measures actual use and not capacity to use, and there is a wide variation in this ratio with various sizes of meters. In the city of Detroit, for example, the average actual use through all ⅝-in. meters is about 2 per cent of the capacity to use at 5-psi. head loss; for all 6-in. meters, the percentage is 16.5.

If all meters in Detroit made a simultaneous demand equal to their several capacities, at a 5-psi. loss, the total demand on the system would be about five times the actual system capacity. Obviously, no water system is designed to meet any such theoretical total of demand but rather the *actual* com-

bined *rate of use* of all customers. One thousand domestic customers never demand 1,000 times the capacity of a $\frac{5}{8}$-in. meter, or, as in Detroit, 50 times the average rate of use. Therefore, individual houses should not be penalized on the basis of meter capacity. If any penalty is assessed, it should be on the basis of the group demand, and there is very little data upon which to base the relative load factors of different classes of customers. It is not uncommon for a residential area to have a sprinkling demand of four times the average, but some industries use most of their water in eight hours a day for five days a week—or in 40 hours out of a total of 168 hours in a week—which would appear to be an eight-hour rate more than four times the annual average.

As a matter of fact, large users of water may often prove more troublesome to a water works system than the domestic users. "Rapid fluctuations in rates of draft from the larger services are often troublesome to small water works systems," states Hazen (4), and business depressions, major strikes and shutdowns for other causes in large industrial centers may seriously reduce the water works revenue, while the whole water system stands by ready to serve. A consideration of these conditions might "logically lead to placing higher service charges on these larger services than would otherwise be used."

The proposition that there should be a service charge for *large* meters "based in a general way upon their carrying capacity" is not new. It has been accepted as a theoretically desirable procedure but one for which "it is no easy matter to get a general basis that will be sufficiently accurate." Obviously, a service charge on a large meter that would maintain any decent revenue from an industry when a plant is shut down, although the water works ready-to-serve costs continue, would be too high for acceptance. The condition poses a problem in rate making for which there appears to be no answer, except that the extra costs are distributed to other users in higher service or commodity rates.

Committee's Rate Base

Early in its discussions the committee proposed to answer two questions:

1. What expenses should be included in a rate base, or what is the formula for determining the amount of revenue that the rates should produce?
2. How may this amount be equitably distributed among the consumers, customers—that is, what should the rate base be?

There is not too much in the literature in answer to the first question, and such statements as appear generally apply to privately owned water works. *Water Works Practice* states briefly that: "The utility is limited by law to a certain amount of return, based on a fair valuation of the property, in addition to operating expenses and an allowance for depreciation."

As there are only one or two privately owned water works in Michigan and the committee is reporting for the particular benefit of Michigan municipalities, it was decided to indicate the differences in approach to this question when considering a publicly owned plant.

There are at least two general bases that may be developed, representing the extremes in practice. The final answer for any particular town will depend

upon the viewpoint of its officials and is likely to be a compromise between the original private-utility basis and the so-called cash basis. Writers on rates have generally followed the theory that a municipally owned water works should prepare its operating budget on exactly the same basis as privately owned water works which have been regulated by courts and commissions. On such a basis a water works is entitled to a gross revenue to cover:

1. The cost of economical and efficient operation and maintenance.

2. Interest. The private company is permitted to earn "a fair return on the fair value of the property devoted to the public use." Obviously, in publicly owned water works much of the plant may be paid for and owned by the municipality. But the higher extreme is to include in the budget an interest return on the net worth of the debt-free property plus, of course, the payment of the interest on outstanding bonds.

3. Depreciation. Most municipally owned plants have followed the practice of charging expense with depreciation allowances at rates that will retire the investment at the end of an assumed life, and the accumulations have commonly been invested in plant extensions.

4. Taxes. A private company pays all taxes—local, school, state, federal and so forth—and there are a few examples of municipally owned plants assuming an equivalent share of taxes. Kalamazoo, Mich., for example, charges expense with all property taxes, federal income tax and surtax, as well as franchise, gasoline and sales taxes.

The above general basis was favored by Hazen (4): "the revenue produced must be sufficient to pay all operating expenses of every description, including the general administration, and this includes, in the case of works owned by cities, a proportionate part of the general expenses of the city government and of the city buildings, a fair allowance for depreciation on all property used, all taxes of every kind, and in addition a return on the value of the plant at the rate at which money can be borrowed for the enterprise."

But the committee was of the opinion that it would be difficult to get public approval of Hazen's program which, he declares, "if systematically followed, will result in constantly increasing surplus revenue, and ultimately part of the surplus should be dedicated to other nonproductive public purposes, such as supplying libraries, hospitals and parks."

The second basis, more generally used by municipally owned plants, is a cash basis, on which the dollars collected are realistically justified by a budget of expenditures that can be made obvious to a city council or commission. The weakness of this method is that unless due provision is made for all contingencies, such as plant extensions, the service may result in operation at less than cost. The cash basis would include:

1. *Adequate* provision, as previously, for operation and maintenance. This means that the organization should have sufficient personnel not only for bare operation but to provide competent supervision and planning, and a wage and salary schedule that will maintain the personnel against the competition of industry and other business.

2. Interest. The only "capital" charge to be included on a cash basis is the *actual* interest and the retire-

ment obligations on the outstanding bonds except that interest on the entire property should be included in fixing rates to suburban areas.

3. Taxes. The inclusion of taxes is a matter of policy for the city administration. According to *Water Works Practice:* "Municipally owned plants are almost without exception relieved from the payment of any taxes on property held or business done within the limits of the owning municipality." The argument for taxes stems from the controversy over private versus municipal ownership, largely in connection with electric rates. As the private ownership of water works has disappeared in Michigan, the inclusion of taxes as an expense in water rates is likely to be limited to those communities that operate both water and electric utilities and exist in an atmosphere of competition with a privately owned electric utility. Like interest, local taxes should be included in the rate base in fixing suburban rates.

4. Depreciation. In lieu of, or possibly supplementary to, the usual "depreciation" allowance, it is important in the cash basis method that sufficient annual sums be collected through rates to provide for all anticipated replacements and all needed normal and current extensions. To what extent the amounts collected should provide for major plant improvements is a question. Some cities have created reserves that finance new projects without resort to borrowing, and there is much to be said for such a procedure.

In any event, liberal allowances to cover the cost of replacements and extensions must be collected through rates, or the water works may find its funds deficient and its operations carried on at a loss. Estimates of specific needs—say, over five-year intervals—are likely to be as much as or more than the ordinary allowances for depreciation, and can more easily secure the support of city officials.

The advantage of the cash or cost basis of fixing the total gross revenue in a municipally owned plant is that it affords a more realistic approach to the facts. Dollars are budgeted for definite needs, and if the budget is sufficient the plant may be adequately maintained and extended as needed. The disadvantage is that if the budget is inadequate, operation at "cost" may mean operation at less than cost and a deterioration in the system and service. But to overcome this disadvantage by including in the rate base interest on the debt-free portion of the water works, or taxes on city-owned property, seems to be a less realistic approach to an adequate budget than a definite justification of cash needs, unless one believes that a municipally owned water works should be a profit-making utility and contribute to other municipal operations.

It may be added that the cash or cost basis complies with Act 94, Michigan Public Acts of 1933, the so-called Revenue Bond Act. Any municipality selling revenue bonds must enforce a rate schedule that will provide adequately for an operation and maintenance fund, a bond and interest redemption fund, a replacement fund and an improvement fund. No depreciation is specified as such, and obviously the law would not require any interest other than for outstanding securities, or any taxes.

The second question is how may the gross revenue be distributed most equitably among consumers. In other

words, what should the rate structure be?

It may not be too far a departure from fact to say that a majority of water rates have been determined, during the past 25 years, or since the adoption of the A.W.W.A. schedule, about as follows:

1. A division has been made of costs into readiness-to-serve and commodity costs. Readiness-to-serve costs have frequently included the total of interest, taxes and depreciation on the entire plant; and sometimes varying amounts of operating and maintenance expense have been added.

The readiness-to-serve costs have first been allocated to fire protection in the form of a hydrant rental and second distributed among customers on the basis of the capacity ratio of the meters. The balance of the costs—so-called commodity costs—are allocated to customers in "step" charges for water. How this is done defies analysis or any reduction of the process to rules. It is done arbitrarily and by reference to precedent and rates in other communities. The nearest approach to a method of fixing water rates is presented in Hazen's book and is essentially a method for checking the revenue to be expected from any particular schedule by reference to experience elsewhere. Sometimes by methods peculiar to the particular writer, the two ends of the rate schedule are determined and the intermediate steps are arrived at by a cut-and-try method.

In contrast, the committee proposes a rate base which may be briefly described:

First, a fire charge should be made to the taxpayers, based largely on the readiness-to-serve theory. An approximately equitable and simple basis is to charge to fire protection that percentage of the total fixed charges which the fire demand bears to the total demand including fire.

In lieu of the readiness-to-serve charge to customers, the committee substitutes a service charge, along the lines originally recommended by the New England Water Works Assn. and Allen Hazen (4) to cover the *service cost,* "including the costs of service pipes and meters . . . and all the costs of reading meters, billing and collecting and any general office expense."

The committee accepts the three steps of the A.W.W.A. schedule and the amounts of water sold under each. The lowest or wholesale step is the total cost of producing and transmitting water. For the intermediate step, one adds to the wholesale step an intermediate increment, the cost of distributing that portion of the water delivered to intermediate users. For the domestic step, one adds a domestic increment, the cost of distributing that portion of the water delivered to domestic customers plus the cost of all lost or unaccounted-for water.

A suggested procedure for applying such a rate base involves the classification of expense and of users and use. All costs or *expense,* including both capital expense (meaning all interest and bond redemption payments and all sums set aside for replacements and extensions) and all operation and maintenance expense, should be classified as:

1. *Production and transmission expense,* or the cost of supplying water to the distribution system, "including all the costs up to the point where the wa-

ter is delivered under pressure at a reasonably central point" (4). Under this classification will come all costs arising out of supply, pumping, treatment, storage and transmission facilities. Transmission mains are those which convey water to the distribution system and are substantially without service taps.

2. *Distribution expense,* "including all the costs that there are for pipes in the streets" (4), but grouped into: [1] all mains larger than 6-in. and [2] all mains 6-in. and smaller.

3. *Fire hydrants and connections,* including all capital, operating and maintenance expense chargeable thereto.

4. *Consumers' services and meters,* "including the costs of service pipes and meters as far as they are borne by the water works department" (4).

5. *Office and shop:* [1] general, including all administrative and overhead costs not specifically chargeable to any particular classification; [2] commercial, including "the costs of reading meters, billing and collecting"; and [3] specific office or shop service costs.

Storage, whether ground or elevated, should be classified by function, as an aid to either production or distribution, since its location has a bearing on the cost of fire protection.

Data assembled on users, pumpage and sales should cover: [1] the number and sizes of meters; [2] the total annual, average daily, maximum daily and maximum hourly pumpage rates; and [3] the total annual sales (total pumpage), broken down into sales to wholesale users, sales through meters larger than $\frac{3}{4}$-in. (except wholesale users), sales through meters $\frac{3}{4}$-in. and smaller and lost or unaccounted-for water.

Fire Protection Charge

A separation of expense chargeable to fire protection may be made on the basis of two assumptions. The first is that fire protection costs are largely "demand" or "readiness-to-serve" costs and only to a small extent "use" costs, as the quantity of water used to fight fires is a relatively small proportion of the total produced for all purposes. The second assumption is that the capital costs chargeable to fire protection "may be determined most equitably by the *ratio* of the maximum fire demand, based on underwriters' requirements, to the total combined demand" for fire plus all other uses.

This ratio is affected by storage, its location—whether at the source of supply or at the end of distribution—and its amount. Sufficient storage, for example, to equalize a ten-hour fire demand over 24 hours reduces the ratio by ten twenty-fourths, while complete lack of storage results in a ratio of maximum hourly demand for fire to maximum hourly demand for fire plus all other uses.

To the proper allocation of readiness-to-serve costs chargeable to fire, as obtained on the above basis, there should be added all *direct* expense arising out of fire hydrants and connections plus a share of administrative costs and overhead.

Rate Structure

The committee's proposed rate structure follows closely the form of the A.W.W.A. rate schedule, adopted May 24, 1923 (1). It consists of a meter service charge plus a commodity charge applied in three steps. These three steps are referred to in *Water Works Practice* as domestic, intermediate and wholesale rates, and this terminology is

adopted for the purposes of the present report. The rules for the application of the schedule follow:

Meter Service Charge

The meter service charge is to include:

1. All commercial expense and a suitable portion of administrative and overhead costs, the total of which is to be divided *equally* to all accounts.

2. All expense arising out of meters and services, with a share of administrative expense and overhead, the total of which may be distributed between accounts on the basis of the *meter* cost, or in the ratios given in Table 1.

TABLE 1

Distribution of Meters and Services Cost

Meter Size *in.*	Ratio
$\frac{5}{8}$	1
$\frac{5}{8} \times \frac{3}{4}$	1
$\frac{3}{4}$	1.5
1	2.25
$1\frac{1}{2}$	4.0
2	6.0
3	10
4	20
6	35
8	50
10	70
12	85

3. There should also be added—probably to the service charge—for all minimum users, the cost, based on the domestic commodity rate, of the minimum desirable use "from the standpoint of sanitary conditions" (4) or, say, 100 gpd. per meter.

Commodity Steps

1. The *wholesale unit rate* is obtained by dividing the total of all production and transmission expense (capital costs and operation and maintenance), plus a portion of administrative expense and overhead, by the total annual pumpage.

2. The *intermediate unit rate* is obtained by adding the intermediate increment to the wholesale rate. The intermediate increment is obtained by dividing the total expense arising out of distribution mains larger than 6 in. by the water sold through all meters, except sales at the wholesale rate.

3. The *domestic unit rate* is obtained by adding the domestic increment to the intermediate rate. The domestic increment is obtained by dividing the total expense arising out of distribution mains 6 in. and smaller, plus the cost of all lost water, by the water sold through all meters $\frac{3}{4}$ in. and smaller.

TABLE 2

Consumption Analysis by Meter Sizes

Meter Size *in.*	No. of Meters	Avg. 3-mo. Consumption *cu.ft.*
$\frac{5}{8}$	195,692	2,406
$\frac{3}{4}$	58,805	4,415
1	9,097	11,369
$1\frac{1}{2}$	3,019	25,591
2	2,219	70,802
3	867	167,333
4	408	521,558
6	231	1,232,684
8	39	2,238,557
10	13	3,644,078
12	9	8,170,500

Step Quantity Limitations

Step quantity limitations must be adopted which, when applied to the unit rates, will produce the necessary revenue, and the quantity limitations and unit rates must be checked as a whole against the system's customers. If the data are not available in the particular system, apparently the best

checking basis available is presented by Hazen (4: Chap. 18) from data tabulated in 1916.

The committee suggests that, as an initial determination of step quantities, the domestic rate apply up to a quantity equal to twice the average consumption through all domestic meters, $\frac{3}{4}$ in. and $\frac{5}{8}$ in.; that the intermediate rate apply up to a quantity equal to twice the average consumption through all intermediate meters; and that all quantities over the intermediate limit fall under the wholesale rate.

It is of interest to apply the above bases to Detroit experience and to the recommended limitations of the A.W.W.A. rate schedule. In Detroit the domestic limit would be nearly 6,000 cu.ft. per quarter, and the A.W.W.A. limit is 9,900. In Detroit, including use through meters from 1 to 4 in., the intermediate limit would be about 90,000 cu.ft. per quarter, which corresponds exactly with the A.W.W.A. recommendation.

Application of Proposed Schedule

Data will not be available in the records of most water departments for the precise application of the committee's proposed schedule.

It should not be too difficult, however, to fix a reasonable figure for the fire protection charge, as it involves three principal items—fire demand based on underwriters' tables, total demand as equalized by storage and total fixed charges.

The data for determining the service charge should be available in the records of most water departments.

As to the commodity unit rates, the wholesale rate, which is based on total production plus transmission costs and total pumpage, will be easily computed. The principal difficulty will be in determining the intermediate and domestic increments, which involve a separation of distribution costs between mains 6 in. or smaller and mains larger than 6 in., as well as estimates of the average annual sales to intermediate and domestic users. Data on sales are given by Hazen (4). Table 2 presents a consumption analysis by meter sizes for Detroit during the year from July 1, 1937, to June 30, 1938.

References

1. *Manual of Water Works Practice.* Issued by the Am. Water Works Assn. Williams & Wilkins Co., Baltimore, Md. (1925).
2. Ludwig, C. C. Water Works—Financing and Rates. Jour. A.W.W.A., **29**:617 (May 1937).
3. Hazen, Allen. Water Rates (Discussion). Jour. A.W.W.A., **9**:528 (May 1922).
4. ———. *Meter Rates for Water Works.* John Wiley & Sons, New York (1918).

The Causes and Prevention of Water Losses

By Homer E. Beckwith

A paper presented on Dec. 7, 1948, at the Southeastern Section Meeting, Augusta, Ga., by Homer E. Beckwith, Dist. Mgr., The Pitometer Co., Pittsburgh, Pa.

IN the water industry the term "waste" covers a multitude of sins and it might be well to pause a while to examine the nature of some of these detours from rectitude. No plant, of course, sells 100 per cent of the water it produces. There are unavoidable sources of waste, which produce in every plant a certain irreducible loss.

Water losses may be due to one or more of a number of causes. "House waste" is a commonly encountered problem. Although the losses from individual leaks in this category may be slight, the total amount of water involved can be very great, because of the large number of such leaks. Losses resulting from underground leakage vary from very small quantities to several hundred thousand gallons a day—even exceeding 1 mgd. on rare occasions—for a single leak. The "slow" meter is another source of water loss, which may range from a few gallons a day on a defective house meter to several hundred thousand on a large industrial meter. A fourth cause of water loss is the unauthorized connection, and again the total may vary widely. This problem is not met with very frequently, but, when it does exist, the losses are often staggering. Defective master meters, underread industrial meters and readings spaced so far apart that the meters have turned over between checks are also responsible for registration losses.

Need for Meter Inspection

All accounted-for figures depend upon the accuracy of the master meter. This instrument is usually of the Venturi or orifice type and is kept in an excellent state of repair, registering accurately year after year. But occasionally something happens. It may be the recording apparatus, which can be easily checked and adjusted, but sometimes foreign matter gets into the throat of the Venturi tube or something else happens to disturb the ratio of the areas at the points where pressures are taken. In the older Venturi type, it was usually not easy to inspect this part of the meter, and without inspection no apparatus can be expected to continue to function properly year after year. Pitometer checks had shown a certain meter to be working perfectly as much as thirty years after installation. That is good service. Shortly thereafter further tests indicated that the meter had begun to overregister, a condition which gradually grew worse over the next few years, finally reaching 30 per cent. An inspection revealed that a large stone had worked its way into the tube and upset the pressure ratios, thereby causing the meter to overregister. In a very small number of meters, the pressure ratios have been affected by tuberculation and false registration has resulted, which is hardly surprising after thirty or forty years of faithful service.

Any piece of scientific equipment is entitled to a reasonable amount of care. Modern Venturi tubes are equipped with handholes to make inspection of the internal condition of the tube easy. Experience has shown that all types of master meters—Venturi, orifice plate, pilot tube or current wheel—perform excellently when properly chosen and properly maintained. But occasional independent accuracy checks by means of some instrument such as the pitometer are of great value in insuring that the figures being used for total water production are accurate.

Domestic Waste

Once assured that the production figures are correct, it should next be determined how much of the water delivered to customers is being profitably used or paid for. Originally all water was sold to domestic customers on a "flat-rate" basis. Some effort was occasionally made to control the amount of water used per service by limiting the diameter of the service pipe, sometimes to ½ in. or even less. These attempts proved ineffectual, however, except in holding down the peak demand rate, since they did little to eliminate the small but persistent leaks which continued throughout the day but which were not of sufficient size seriously to affect the pressures or the supply of water for normal use.

There are two methods in general use for controlling domestic water waste. One is the examination of house fixtures by qualified inspectors, either on an overall or a selective basis, with penalties invoked for failure to keep plumbing in a good state of repair. The other method is the installation of meters on domestic services, again either completely or selectively. Which means should be chosen is a matter of economics, depending on the amount of the existing waste and its cost. Some small cities, where there are no sewer systems and where persistent fixture waste will quickly cause cesspools or septic tanks to overflow, may have a per capita consumption of as low as 40 gpd. Unless this water has a high production cost, it may be uneconomical to spend much money to reduce the loss. In other cities, where facilities exist for draining off the waste without inconvenience to the wasteful consumer, the per capita use and waste of water may reach 300 or even 400 gpd. Even with low-cost water, some effort to control wastage is clearly indicated when consumption is anywhere near this high. Inspection and forced repair of defective plumbing fixtures may serve the purpose, but more and more cities are resorting to the metering of domestic services. In order for this method to be effective, the meters must be kept in repair and read at proper intervals.

Registration Losses

The author has always felt that sensitivity is a trait more to be desired in a domestic meter than extreme accuracy. The meter is a mechanical device and it takes energy to move it. The energy necessary for sufficient water to slip around the working parts of the meter and cause a small but steady drip is so little that few if any of the meters in current use will register it. How large an amount can slide through without causing the meter to turn depends on its sensitivity—its inertia or resistance to movement. And the sensitivity of the meter determines the size a fixture leak must attain before it begins to cost the customer money. It must not be forgotten that small drips will usually not register on even the newest and best of the meters in popular use. Such leaks therefore become

one of the items in the total of unaccounted-for water. Furthermore, a little reflection will show that the amount lost depends upon the number of meters and not upon how much water flows through the meters. As the average use through each meter increases, the percentage of loss from drips decreases. Meters which may be 100 per cent accurate at a relatively high rate of flow but which do not start to register until an appreciable flow occurs are a fertile source of loss. On the other hand, a meter which causes an increase in the water bill whenever a relatively small fixture leak is permitted to persist makes the customer "waste minded" and cuts down the amount of wasted water.

Loss in registration can also result from too infrequent reading of the meters. The author recalls one city where the careful investigation of a night flow rate of approximately 30,000 gpd. in a single block failed to disclose any indications of underground leakage. Inspection revealed that several meters were turning at a constant rate of ¼ cfm. or more—over 360 cu.ft. a day or 130,000 cu.ft. a year. As the meters were only read once a year, and as the capacity of the reading dial was only 100,000 cu.ft., the meters turned completely over between readings and the customers were billed for only part of the water actually used. There were indications that some of the meters had turned over at least twice between readings. The remedy here manifestly is more frequent readings or an in-increase in the capacity of the reading dial. Some smaller industrial meters turn over between readings which are six months apart.

Several years ago a survey in a certain small city brought to light the fact that the high loss was almost entirely the result of underreading the large industrial meters. The smallest reading unit on the large meters was ten times the size of the smallest unit on the domestic meters and was so marked. The meter reader, however, paid no attention to the markings and year after year read the meters at 10 per cent of the actual consumption.

In passing, it might be mentioned that cubic-foot meters occasionally get mixed into a system where all the rest are gallon meters, or vice versa, and incorrect readings result.

Another source of lost water, or at least lost registration, is the industrial meter which does not accurately record the flow through it, because the meter is worn out or otherwise defective, or because it is improperly set or unwisely selected. Manufacturers make several types of meters, each of which is especially designed to do a certain kind of work. Some perform best under high continuous flows, some under relatively low flows and some under a combination of both. Moreover, the manufacturer's instructions about setting the meter must be followed or incorrect registration may result. Satisfactory service can be assured only if meters are correctly chosen as to type and size and are properly set.

Meters are mechanical instruments and even the best machines eventually wear out. Although registration may continue, worn gears and other frailties of old age gradually decrease meter accuracy. Meters are the cash registers of the water works system and justify every bit of attention and care required to keep them in proper working condition.

Occasionally it will be found that industrial customers are taking water through unauthorized connections or unmetered fire lines—often in spectacular amounts. The author knows of one plant which took nearly 2 mgd. and

had apparently been doing so for 25 years. It is remarkable, however, that in most such instances the top management of the offending company has no knowledge of what is taking place. Some minor official is usually just trying to make a showing. Most people are honest.

Underground Leakage

The source of greatest losses is the hidden, underground leak, which may vary in size from a few gallons a day to over a million. Underground leaks occurring on mains are usually due to blown joints, broken or split mains, holes, rotted wooden plugs and the like. Those on services are due principally to broken corporation cocks, defective wiped joints, blown gaskets, split pipe, or pipe disintegrated by corrosion or electrolysis. The escaping water gets into sewers, gravel beds, culverts, streams, limestone caves and so forth. Even after more than 25 years' experience in detecting and locating leaks, the author is frequently surprised by some new combination of circumstances which will permit water to escape from such a leak without any surface indication of its existence. The increase in the amount of paved streets has been a factor in keeping many leaks hidden.

As previously stated, some leaks are too small to be detected by any presently known method, and, even if they were definitely located, the cost of repairs would be excessive. These small leaks are an important factor in irreducible losses. Here again, the amount of loss depends on the size and number of the mains and not on the quantity of water they carry. If the water use from a particular pipe were doubled, the increase would not cause a single gallon more to be lost from that pipe. In other words, the percentage ratio of the seepage to the use would be cut in half.

Other factors, such as leakage and evaporation from reservoirs, also contribute to the irreducible loss.

Water Waste Surveys

The three principal causes of irreducible losses are fixture drips too small to register on meters, small seeps from mains, and evaporation and other reservoir losses. None of these three bears any direct relation to the amount of water put into the system. For this reason, it is impossible to give any overall figure for reasonable losses. Some plants should, and do, account for approximately 90 per cent of the water produced. Others, with a very low per capita use or an excessive main mileage in relation to the amount of consumption, can under the best of conditions account for only a much smaller percentage. It requires a water waste survey, planned in such a way that it will detect and locate all of the preventable sources of waste, to determine what the unavoidable loss is on any particular system.

The pitometer water waste survey is intended to be that type of survey. It is based upon a series of direct and indirect measurements with the pitometer which determine the amount of water entering the system and its distribution throughout the system. A properly designed pitometer survey has several functions:

1. It checks the master meters for accuracy by independent comparative flow measurement.

2. It divides the distribution system into districts containing a few miles of main each and obtains a 24-hour measurement of the total flow into each district, together with the variation in that flow.

3. It tests large industrial meters for accuracy by independent comparative flow measurement.

4. It checks large industrial plants for unauthorized connections, again by flow measurement.

5. It determines the distribution of the night rate of flow almost block by block, so that the location, as well as the amount of the waste, can be determined. Through further investigations conducted by suitable methods wherever these measurements show abnormal flows, all leaks are definitely located for repair and all other sources of waste are disclosed.

That is to say, the survey tells where the water goes and why it goes there. It eliminates guesswork and clearly shows the exact nature of the waste, so that remedial steps may be taken. Underground leaks are located and can be dug up and repaired. If residential waste is involved, the responsible areas, or even individual properties, are discovered, making possible the elimination of the waste by inspection and repairs or by metering. Defective industrial meters or unauthorized industrial use is detected, and the meters can be repaired or replaced. If it is found that meters are not being read often enough, the period between readings can be shortened. Once the disease has been correctly diagnosed, the remedy is clearly indicated.

When such a survey has been made and all the waste stopped, then and only then can the percentage of "unavoidable" waste for a particular plant be determined.

A question frequently asked is what size of community can profitably make a water waste survey. The answer is that there seems to be no maximum or minimum limit. Some of the most outstandingly successful surveys have been made in communities of more than a million population, while others have been equally successful in communities of less than a thousand population. A single leak wasting 50,000 gpd. would be a very small item in a system using 100 mgd., but in a small community with a total daily consumption of 100,000 gal. it would amount to half of the output. Although most of the really large individual leaks have been found on the larger systems, the surveys which have resulted in the highest percentage of water loss reduction have usually been made on smaller plants. The operation of the survey is flexible, and methods are readily adaptable to the various field conditions encountered—including the size of the community.

The amount of "preventable" waste which should be permitted to exist before a determined effort is made to locate and eliminate it depends on the value of the water—its cost of production, the quantity available and other widely varying factors. The least valuable water is probably that taken from a gravity supply having surplus storage and transmission capacity, although as the demand approaches the capacity of the plant this water can become extremely precious. Most expensive is the water obtained from limited supplies with high purification and softening costs. Each system has to be studied upon the basis of local conditions, but there will always be a point at which waste becomes too costly to be tolerated. When that point has been reached or passed, a careful, scientifically planned survey such as the one previously outlined will best serve to bring the losses down to a minimum.

Measuring Pump Performance During Operation

By N. C. Ebaugh

A paper presented on Nov. 19, 1948, at the Florida Section Meeting, Panama City, Fla., by N. C. Ebaugh, Head, Mech. Eng. Dept., Univ. of Florida, Gainesville, Fla.

PUMPING costs are one of the major operating expenses of water supply systems. Hence, it pays to keep close check on the performance of the pumps to be sure that they are operating at peak efficiency and that the pump and motor have been selected correctly in the first place. After having inspected pumps for twenty years, the author is still surprised to find a considerable number which were not properly chosen and which are greatly overmotored.

The object of this paper is to present methods of measuring pump performance while in operation so that pumps which are poorly selected or which are not performing as they should can be readily detected. The methods given are for field checking purposes and cannot therefore be expected to have the high accuracy attained in the laboratory.

Four quantities must be measured in order to check pump performance properly: the total head, the input horsepower, the quantity of water pumped and the rotation speed. These measurements must be taken simultaneously under the same conditions while the flow, head and speed are steady. Other flow rates are then taken if the whole performance curve of the pump is desired.

Pump Heads

A typical high-head pump arrangement for a water plant is shown in Fig. 1. The total head (H_t, in feet) developed by the pump for this arrangement is given by Eq. 1 and represents the actual amount of useful

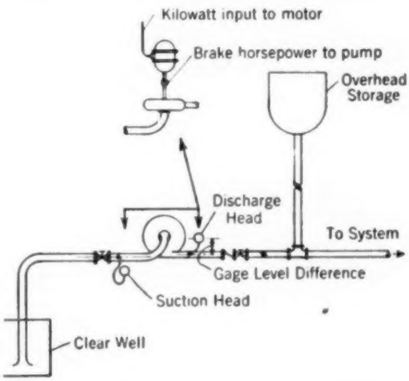


FIG. 1. High-Head Pump Installation

energy that the pump imparts to each pound of water:

$$H_t = H_D - H_s + H_{GD} + H_{V.D} - H_{V.s} \quad (1)$$

In this equation, H_D is the discharge gage pressure, in feet, equaling 2.31 times the gage pressure in pounds per square inch; H_s is the suction gage reading, in feet, equaling 1.13 times

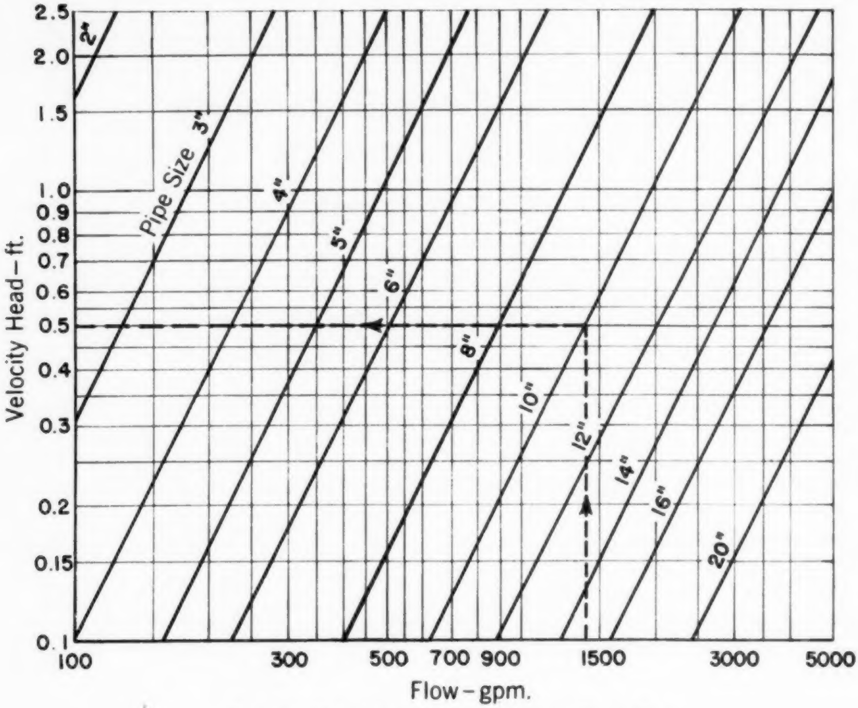
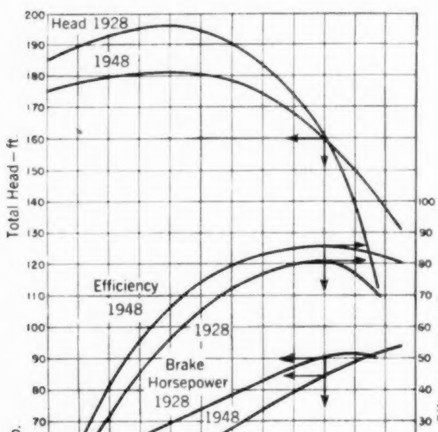


FIG. 2. Velocity Head for Various Flow Rates



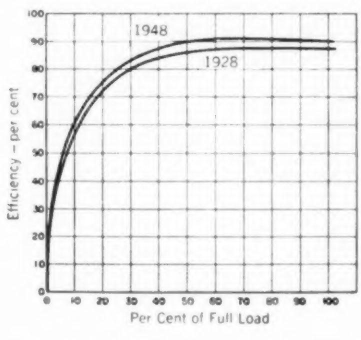


FIG. 3. Comparison of Pump Characteristics *

FIG. 4. Motor Efficiency Curves †

* Data from American-Marsh Pumps, Inc.
† Data from Westinghouse Electric Corp.

the gage reading in inches of mercury; H_{GD} is the gage level difference, in feet, equaling the discharge gage center elevation minus the elevation of the suction gage *connection;* $H_{V,D}$ is the velocity head in the discharge pipe, in feet; and $H_{V,s}$ is the velocity head in the suction pipe, in feet, equaling the square of the velocity, in feet per second, divided by 64.34.

The gages used should be calibrated with a dead-weight tester and care should be taken not to use pipe connections larger than $\frac{1}{4}$ in. for the gages. The gage pipe connections should not extend beyond the pipe wall but should be flush and free of all burrs on the inside.

The velocity head, which is the energy the pump has to put into the water to bring it up to the speed in the pipe, may be taken from Fig. 2. For example, the velocity head for 1,400 gpm. flowing in a 10-in. pipe is 0.5 ft.

Horsepower and Efficiencies

The actual horsepower (whp.) imparted to the water as it flows through the pump will be:

$$\text{whp.} = \frac{H_t \times \text{gpm.}}{3{,}960} \quad \ldots\ldots (2)$$

with H_t being the total head, in feet, and "gpm." the pumping rate in gallons per minute.

The input shaft horsepower or brake horsepower from the motor is greater than the water horsepower because of the various hydraulic and mechanical losses of the pump. The brake horsepower (bhp.) is given by:

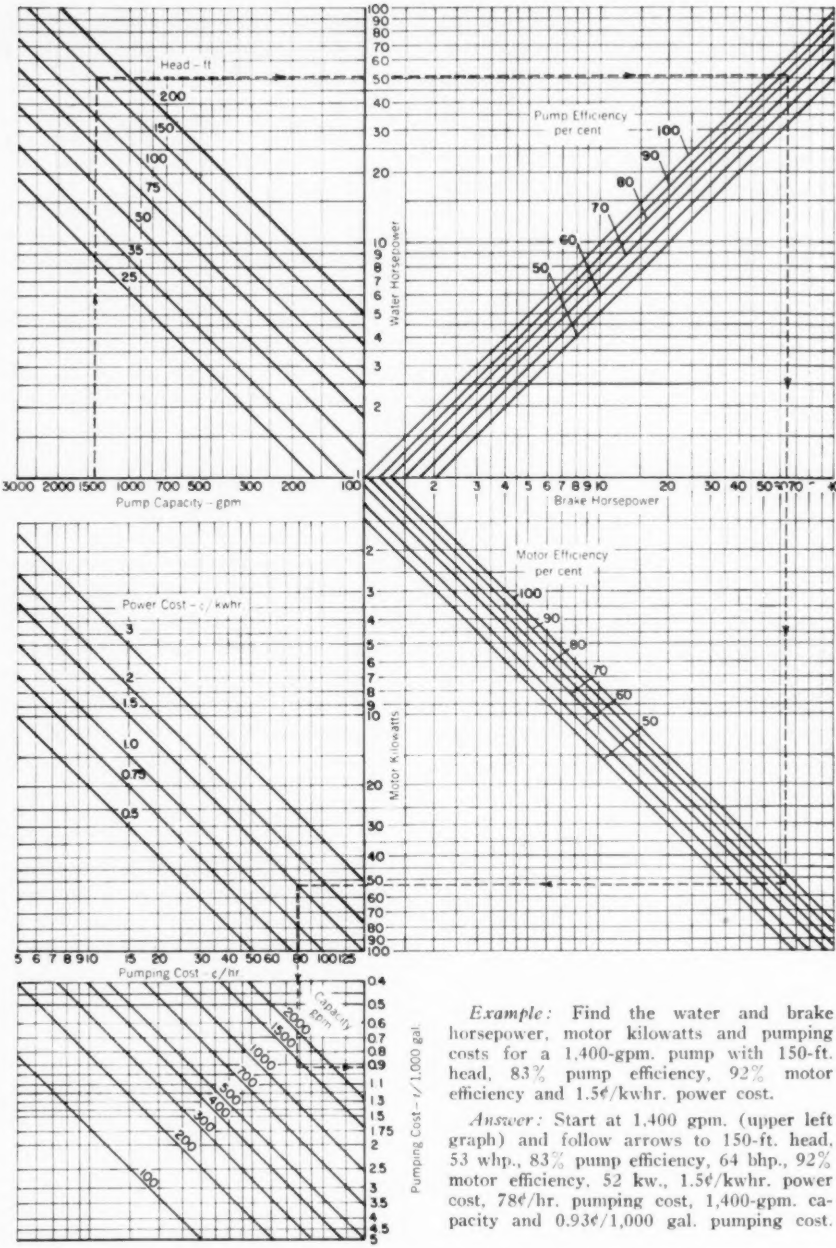
$$\text{bhp.} = \frac{100 \text{ whp.}}{\text{pump efficiency } (\%)} \quad \ldots (3)$$

The electrical power input to the motor is greater than the brake horsepower output because of the electrical and mechanical losses within the motor. The kilowatt input, then, is given by:

$$\text{kw.} = \frac{74.6 \text{ bhp.}}{\text{Motor efficiency } (\%)} \quad \ldots (4)$$

Typical pump and motor performance curves are shown in Fig. 3 and 4. The motor data in Fig. 4 are not for the pumps of Fig. 3 but may be taken as representative. Two sets of data twenty years apart are presented to bring out the magnitude of the improvements made during this period. The peak efficiency of the 6-in. pumps (1,750 rpm., 1,800-gpm. capacity at 160-ft. head) shown in Fig. 3 was raised from 81 to 86 per cent. The peak efficiency of the 30-hp., 220-v., three-phase, 1,750-rpm. induction motors shown was raised from 87.5 to 90.5 per cent. The combined efficiency, or wire-to-water efficiency as it is sometimes called, has increased from 71 to 78 per cent, which means that almost 10 per cent of the pumping cost may be saved, as compared with a 1928 installation, by changing to a modern pump and motor. This does not take into account twenty years of wear which makes modernization even more attractive. To put it another way, a 10 per cent saving for the pumps shown in Fig. 3, at a rating of 1,800 gpm. and a 160-ft. total head, means that $1,350 a year will be saved if the pump operates continuously and power costs 2¢ per kilowatt-hour.

A convenient chart for quick estimates of water horsepower, brake horsepower, kilowatts and pumping costs per hour and per 1,000 gal. is given in Fig. 5. This chart is also useful for checking the accuracy of computed results from pump tests to detect gross errors of calculation.



Example: Find the water and brake horsepower, motor kilowatts and pumping costs for a 1,400-gpm. pump with 150-ft. head, 83% pump efficiency, 92% motor efficiency and 1.5¢/kwhr. power cost.

Answer: Start at 1,400 gpm. (upper left graph) and follow arrows to 150-ft. head, 53 whp., 83% pump efficiency, 64 bhp., 92% motor efficiency, 52 kw., 1.5¢/kwhr. power cost, 78¢/hr. pumping cost, 1,400-gpm. capacity and 0.93¢/1,000 gal. pumping cost.

FIG. 5. Estimating Horsepower, Kilowatts and Pumping Costs *

* 10 × 6½-in. chart available from A.W.W.A.; price, 10¢.

Power Measurement

One of the most convenient ways of measuring the power output of induction motors, without interrupting their operation, is with a hook-on volt-ammeter such as the one shown in Fig. 6. Usually there is enough slack in the wires in the motor starter box to take readings for each phase—the method given here pertains to three-phase circuits but can be adapted to others. The average current of the three phases is then divided by the full-load amperes, as stamped on the nameplate of the motor, and the power output obtained from Fig. 7 (1). For example, if the average current for an 1,800-rpm., 220-v., 30-hp. motor with a full-load current of 75 amp. is 50 amp., 50/75 equals 67 per cent of the full-load current, and the power output is 62 per cent of 30 hp., or 18.6 hp. This example is shown by the dotted lines on Fig. 7.

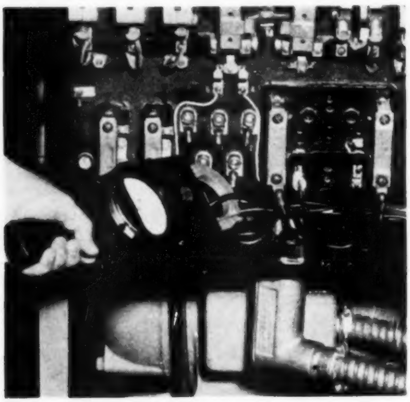


FIG. 6. Hook-on Volt-Ammeter

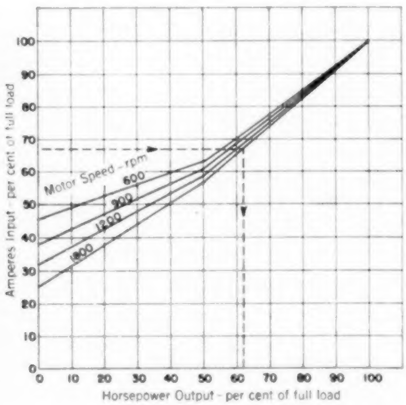


FIG. 7. Estimating Horsepower Output

The volt-ammeter is convenient for checking to see that the motor nameplate voltage is maintained, and it will also reveal any serious unbalance between the three phases. This method of power measurement should usually yield results accurate to within about 3 per cent.

Another method of determining power is with the aid of the watthour meter. A watthour meter installed on the pump control panel can be used, or, if the rest of the plant can be shut down, the plant watthour meter may be used.

The procedure is simply to count the number of revolutions of the meter disc for a timed interval (three minutes is usually enough) during which the water measurements are taken. The electrical input to the motor is given by the equation:

$$\text{kw.} = \frac{3.6RK}{S} \qquad \ldots\ldots\ldots(5)$$

in which R is the number of revolutions of the disc in time S; S is the time of the test, in seconds; and K is the overall meter constant.

The meter constant is usually shown on the disc as $K = 0.6$ or on the meter nameplate as $K_h = 0.6$. A constant of 0.6 means that 0.6 whr. of electricity is used for each revolution of

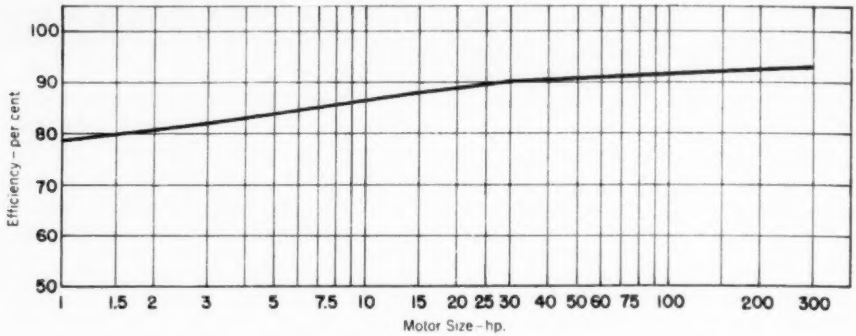


FIG. 8. Three-Phase Motor Efficiencies for Half Load or Above

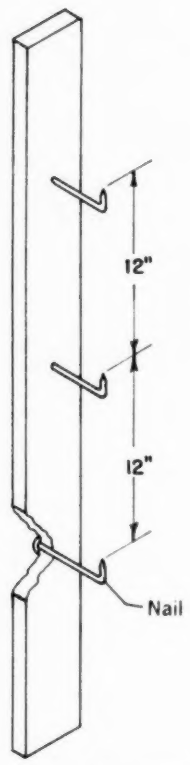


FIG. 9. Improvised Hook Gage

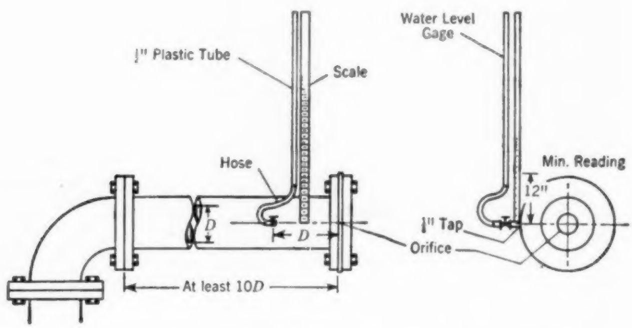


FIG. 10. Open-End Orifice Plate for Pump Testing

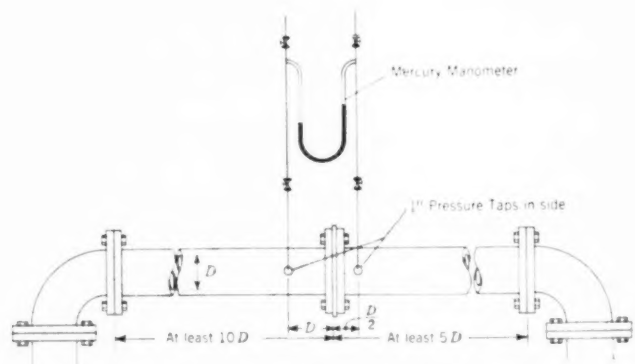


FIG. 11. Alternative Orifice Plate Installation

the disc. Of course, the constant may have other values. If potential and current transformers are used with watthour meters, as is frequently done, their stepdown ratios must be used to get the overall meter constant, K.

To illustrate, assuming that the meter constant is 0.6 with a 10:1 potential transformer and a 5:1 current transformer, the overall meter constant is (0.6)(10)(5) or 30 whr. per revolution.

The brake horsepower output of the motor is obtained from the equation:

$$\text{bhp.} = \frac{\text{kw.} \times \text{motor efficiency (\%)}}{74.6} \quad \ldots(6)$$

Motor efficiencies for typical alternating current motors with half load or more are given in Fig. 8. The accuracy of this method should be about as good as that with the hook-on voltammeter method. For example, assuming that an overall meter constant of 0.6 applies to a 100-hp. motor being tested, it is desired to find its brake horsepower output if the meter makes 123 revolutions in three minutes. From Eq. 5, the kilowatts to the motor will be $(3.6)(123)(30) \div (3)(60) = 73.8$ kw. Since Fig. 8 shows a 91 per cent efficiency for a 100-hp. motor, the brake horsepower given by Eq. 6 is $(73.8)(91) \div 74.6 = 90$ bhp.

Water Measurement

Accurate measurement of pump capacity is usually more difficult to make in the plant than either head or power measurements. Sometimes a plant Venturi or orifice meter exists which can be valved to measure the flow from one pump at a time. If the meter has been checked for accuracy, the problem is easy, but more often other means have to be employed for field testing, such as measured tanks or filter basins, orifice plates, pitot tubes or weirs. Weirs will not be considered in this paper in order to keep it to a reasonable length.

If the pump discharge can be diverted into a filter or a tank which has been carefully measured, the capacity can be determined by timing the rate of level rise with an improvised hook gage and a stopwatch. This will give the cubic feet per minute flowing, and the gallons per minute can easily be secured. Sometimes the tank may be more conveniently located on the pump suction side rather than on the discharge side. A satisfactory hook gage can be made by nailing through a 1 × 4-in. board and turning the ends of the nails up as shown in Fig. 9. The time for several successive nail points just to break through the water surface should be taken to secure check readings.

Frequently orifice plates offer a fairly simple method of field testing, particularly for well pumps. The orifice in the plate should be lathe-cut and not over $\frac{1}{16}$-in. thick, and the upstream edge must be sharp and free of all burrs but not rounded. The plate is concentrically bolted to the end of a flanged pipe as shown in Fig. 10. Sometimes the plate can be slipped between the flanges of a straight run of pipe as in Fig. 11. Care must be used when putting in the $\frac{1}{8}$-in. pressure taps to see that they are smooth inside with no burrs and that they do not extend past the pipe wall.

The flow (Q, in gallons per minute) indicated by an orifice plate is obtained from the formula:

$$Q = 5.68Cd^2\sqrt{h_w} \quad \ldots\ldots(7)$$

in which C is a coefficient dependent upon the ratio of the orifice diameter to the internal diameter of the pipe; d is the orifice diameter, in inches; and h_w is the differential pressure on the orifice, in inches of water.

If the arrangement of Fig. 11 is used with a mercury manometer completely filled with water over the mercury, a more convenient equation is:

$$Q = 20.2Cd^2\sqrt{h_m} \quad \ldots\ldots (8)$$

in which h_m is the differential pressure on the orifice, in inches of mercury.

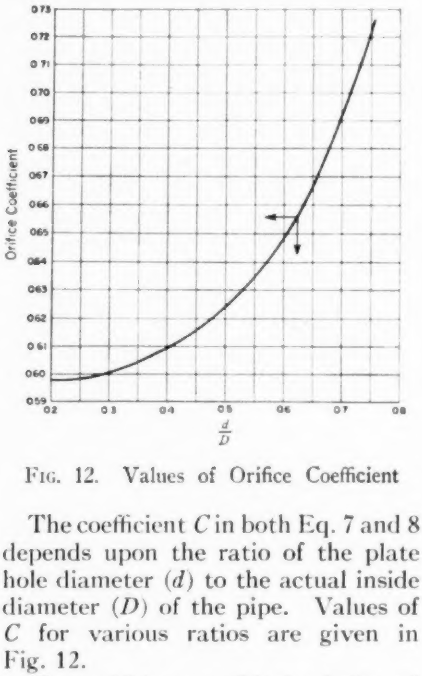


FIG. 12. Values of Orifice Coefficient

The coefficient C in both Eq. 7 and 8 depends upon the ratio of the plate hole diameter (d) to the actual inside diameter (D) of the pipe. Values of C for various ratios are given in Fig. 12.

Figure 13 is a graphical solution of the theoretical flow of the orifice exclusive of the coefficient C. Values from Fig. 13 have to be multiplied by C from Fig. 12 to get the actual flow. Figure 13 is also helpful in selecting the proper size of plates for a test.

The pitot tube, invented in 1730 by the French engineer Henri Pitot, is still one of the best devices for making field measurements of the capacity of pumps. The arrangement of the tube, as successfully used for many years by Gregory (2), is shown in Fig. 14(a) and the points in the pipe where the tube is placed are shown in Fig. 14(b). A tube which is a slight modification of Gregory's and which is built in accordance with the standards of the Hydraulic Institute can be inserted through a standard 1-in. corporation cock or a 1-in. gate valve. Ten diameters of straight pipe should be ahead of the tube position and five diameters should be after it.

Because the pitot tube measures the velocity of the water at a point, a traverse of the pipe must be made to determine the average velocity. Usually ten readings are sufficient for field work. The tube is placed at the points shown in Fig. 14(b) and each differential pressure is converted to velocity (V, feet per second) by:

$$V = 2.32\sqrt{h_w} \quad \ldots\ldots (9)$$

in which h_w is the differential pressure, in inches of water. The flow is then secured from the internal pipe diameter (in inches) and the average of the ten velocities by the formula:

$$Q = 2.45D^2V_{avg} \quad \ldots\ldots (10)$$

If sufficient straight pipe is available to give a symmetrical flow pattern in the pipe, the average velocity is approximately equal to 0.84 times the velocity indicated at the center of the pipe.

Pump Speed

It is necessary to measure the rotation speed of a pump when checking its performance and to correct all readings to a single speed before plotting the results as in Fig. 3. The speed can be taken with a calibrated ta-

chometer or a simple revolution counter and stopwatch.

The motor speed will vary slightly at the several load points during a test and the following formulas can be used to correct to one standard speed, S_s:
Capacity at S_s:

$$\text{gpm}_s = \text{gpm}_m \frac{\text{rpm}_s}{\text{rpm}_m} \quad \ldots\ldots(11a)$$

Head at S_s:

$$H_s = H_m \left(\frac{\text{rpm}_s}{\text{rpm}_m}\right)^2 \quad \ldots\ldots(11b)$$

Referring to Fig. 1 and assuming that 1,800 gpm. is needed, and that the lift of the water from a full clear well level to a low level in the overhead storage tank is 120 ft., the head required to pump various amounts of water to the system will be given by the minimum system head curve in Fig. 15. A high-lift condition would require a lift of 150 ft., and this maximum system head curve is also shown in Fig. 15. The two conditions given here are purposely exaggerated as compared with usual operating practice.

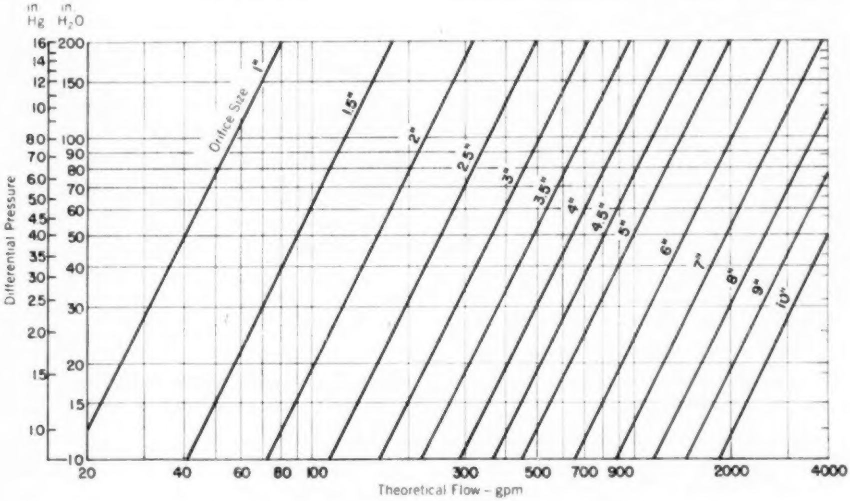


FIG. 13. Theoretical Flow for Orifice Plates

Horsepower at S_s:

$$\text{bhp}_s = \text{bhp}_m \left(\frac{\text{rpm}_s}{\text{rpm}_m}\right)^3 \quad \ldots(11c)$$

The subscript s refers to the standard speed and the subscript m to the measured speed at each test point.

Determining Proper Selection

All of the foregoing measurements are incidental to the main question of whether or not the pump is selected properly and whether it is operating properly in a given system.

If the head-capacity curve for the 1948 pump is taken from Fig. 3 and put on Fig. 15, it will cross the two system curves at points A and B. It is important to note that once the pump is connected to the system it can operate only between these two limits and along its own head-capacity curve. In this example, the limits are from 1,610 to 2,030 gpm., and the pump should be specified for 1,800 gpm. at 160-ft. total head, as this would be close to its usual operating condition.

Examination of Fig. 3 shows that the pump develops its maximum efficiency in this range.

A test will show whether or not the pump is properly selected for operating near its peak efficiency. Also, a curve similar to Fig. 3 will be furnished by the pump manufacturer for each pump, and the test results can

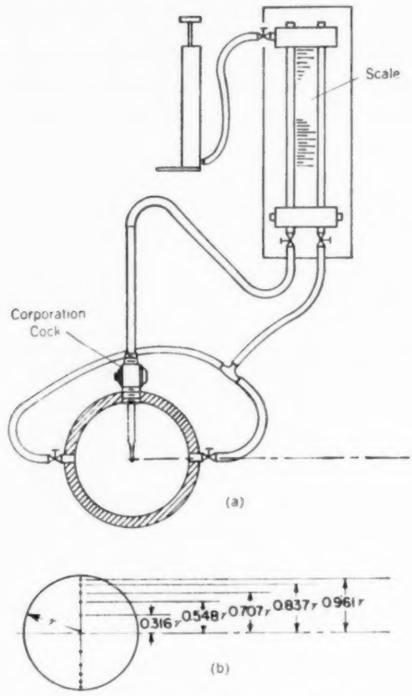


FIG. 14. Pitot Tube Installation

easily be compared to determine if the pump performance is up to design value.

Summary

The data and methods presented in this paper may be briefly summarized:

1. It has been shown that the replacement of twenty-year-old pumps and motors may result in worthwhile savings in pumping costs.

2. Field methods of measuring pump head, horsepower, kilowatts input, capacity and speed have been presented.

3. Convenient graphical methods of estimating and checking pump performance have been given.

4. The determination of whether or not the pump is performing in accordance with its design characteristics can be made with the aid of the methods and data given.

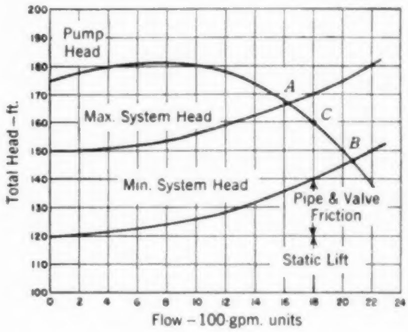


FIG. 15. Pump Selection for Maximum Efficiency

5. A method for ascertaining whether or not a pump is properly selected has been given. It has been shown that a pump can operate only within the limits determined by the system head-capacity curves and that it is important for the balance point to correspond to the peak of the pump efficiency curve.

References

1. SETTER, JOSEPH A. Motor Horsepower From Ammeter Readings. Southern Power & Ind. (Jan. 1943).
2. GREGORY, W. B. The Pitot Tube. Trans. A.S.M.E., **25**: (1904).

Maintenance of Electrical Equipment

By W. J. Seibert

A paper presented on Nov. 19, 1948, at the Florida Section Meeting, Panama City, Fla., by W. J. Seibert, General Electric Co., Atlanta, Ga.

MAINTENANCE should be considered as a production tool and not as a necessary evil. Adequate facilities for maintenance should be incorporated in plant design. Motors and pumps should be placed so that there is enough room around them to permit inspection. The equipment should not be crowded into pits or against walls, where it is almost impossible to remove a rotor. Future expansion should also be taken into account.

The present paper will deal with the maintenance of electrical equipment.

If a water works has its own substation it is well to check the bushings about once a year as they become coated with various substances from the atmosphere and dust and dirt from the surrounding plants. This material may be conducting and cause a flashover. Furthermore, the bushings may be under strain from the connections and the cement seal may become cracked, or the gaskets may develop a leak. All these things should be taken into consideration, but if the power company owns the substation it will not be necessary for the operator to do any routine checking except possibly to notify the company of any leaks or irregularity in the bushings.

Transformers

As compared with most electrical apparatus, transformers need little attention. The extent of the inspection and maintenance required will be governed by the size, the importance of service continuity and operating conditions. Distribution transformers and small transformers ordinarily require and receive less attention than large ones. When small transformers supply power to industrial loads where, as in water works, continuity of service is of the utmost importance, a greater degree of attention is justified.

Before the transformers are energized, it should be made certain that the insulating liquid is at the proper level to insure satisfactory continuous operation.

If the transformer is of the type which is open to the atmosphere—that is, has a breather so that air can be drawn in and expelled when the oil gets hot—the cover should be removed every year to see if moisture is accumulating underneath it. This is not likely to happen when the transformer is loaded continuously, unless a bushing is cracked or there are leaky gaskets. Every five years the core should be removed and checked for sludge and for rusting in the interior of the transformer. The transformer should be raised out of the tank and both the tank and the core washed with oil under pressure. After washing, the oil should be drained from the part cleaned and all the sludge and dirt should be removed from the tank. The oil should then be

refiltered and checked to see that its quality is good enough so that it can be put back into the transformer.

Cables and Wiring

It is a mistake to regard cable and wiring as permanent installations requiring no maintenance, as they can and frequently do cause considerable trouble. In some of the older stations, cables are run in a hit-or-miss manner and may have no conduit covers. They are very often crossed and one or more of the cables may be subject to pressure which will gradually wear through the insulation. Frequently cables in floor channels are so placed that they are not ventilated and run hot, causing the insulation to deteriorate. Cables should be run properly in ducts or conduit so that any heat generated will be dissipated. Furthermore, all connections through cables should be checked periodically to see that they are not working loose and producing heat which will eventually ruin the cable. Proper lightning arrestors should be employed to protect the various parts of the installation. Lightning arrestors in conjunction with capacitors will flatten out the steep wave front of a surge and reduce the stress on the various machines. Cheap protection and good insurance are provided by this method. A good ground is most important in installing lightning arrestors. Ground resistance should be measured at least once every two years to see that no connections are broken and that the rods, or whatever means of grounding are used, are adequate and have not deteriorated.

Switchgear and Control Devices

Switchgear is a vital factor in the operation of any plant and should be given as careful maintenance as any other piece of apparatus. When switchgear is installed it should be carefully checked to make certain that all connections are tight, both on the power lines and on the instruments. After twelve months the contacts should be examined to see that there is sufficient life, that they have not been badly burned and that no accumulation of dirt or oxide has formed which may interfere with the conduction of the various contacts. All cable connections should be checked to see that they are not overheating and that all joints and connections are intact and in good condition. Small bolts and insulators should be tight and all cotter pins in place. In general, a circuit breaker requires very little lubrication, and care should be taken that there is no excess of oil or grease to accumulate dust. The parts of the tripping mechanism and latches should move freely so that there will not be a hangup when the device is supposed to operate.

Mineral spirits or naphtha should be used in cleaning the various parts on the supports, as some of the new solvents may attack the plastic. The switch should be operated several times without current to check the contact area, the secondary and the service. Perfect contact will go a long way toward preventing overheating and deterioration. The undervoltage devices should be carefully checked to see that they will trip out at the proper point and take the machine off the line when the service is interrupted.

The bus bars should be inspected at least once every twelve months for overheating, and if the connections are loose they should be properly retightened, after cleaning the bus to see that there is a good copper-to-copper connection. If heating still persists, it may be necessary to silver-plate the joints, which can be done very readily by the brush-plating method. The contacts

should not be filed frequently unless there is a distinct sign of burning. Contacts which are pitted may still be in good operating condition and it will not be necessary to dress or renew them unless they are actually burned to a point where they are causing trouble. Silver contacts should be dressed just as little as possible as they generally have a secondary contact to take the arcing and the silver is not required to withstand burning or arcing.

Industrial control devices require frequent inspection and considerable maintenance to assure good operation because the contactors develop a certain amount of hammer which has a tendency to jar the apparatus. The controls should be inspected monthly for collections of dirt or gum. The excess heating of parts may be shown by the discolorations of the metal or by charred insulation or leads. All parts must be free and none should be corroded or worn beyond the limit. Proper contact pressure should be maintained and flexible shunts should be checked. The overload relay should be checked for excessive heating, which is generally caused by loose connections, and the condition of the heating elements should be examined periodically.

Oil-immersed contacts should be checked every six months to see that the oil is in good condition and the contacts tightened. Arc shoots and barriers of air breakers should also be checked twice a year to prevent burnt spots from short-circuiting the breaker.

Motors

Dirt causes more failures in motors than any other single factor. Open-type motors should be frequently blown out with air at approximately 15 psi. pressure. All nuts, bolts and mechanical parts of the motor should be tightened. Care must be used in blowing out a motor so that none of the dirt which has accumulated is blown into the bearings, as even a slight amount, especially in ball bearings, can ruin them very quickly. In wiping electrical apparatus, a clean, lint-free rag should be used. If it is impossible to shut a motor down in order to blow it out or to clean it, care must be taken to see that the dust dislodged from the winding does not impede the operation of the apparatus. Occasionally a motor will become soaked by oil leaking out of the bearings and being thrown into the winding, and the dust will accumulate on this oil deposit, making it impossible to blow the motor out satisfactorily. In that event, it is necessary to disassemble the motor and clean it with a proper solvent. Normally mineral spirits should be used, but if the location is dangerous and the fire hazard too great, a mixture of mineral spirits and carbon tetrachloride may be employed which will not affect the windings. Caution is required, however, because a man can become seriously ill from breathing a great amount of carbon tetrachloride fumes.

Moisture can be very detrimental to the windings of a motor. Even though there is no direct spray of water on the windings, they will absorb a certain amount of moisture from the atmosphere when they are standing idle. But there is no danger of moisture accumulating when the motor is running, as it is above the ambient temperature and there will be no absorption. When motors are allowed to stand idle in a damp atmosphere small heaters should be placed in the frame somewhere to keep the temperature two or three degrees above the ambient temperature. The heaters can be interlocked with the control circuit so that when the motor is running, the

heaters are off. This is about the best assurance that a motor will be dry.

For standard a-c. motors, the maintenance is rather simple and consists of keeping them clean and dry, examining the bearings about once a year, checking for loose bolts in the coupling on the motor frame and in the base, and seeing that there is no vibration present due to misalignment or loose bearings and couplings.

Synchronous motors should be inspected in the same way as induction motors. Collector rings should be checked periodically for wear and also to see that no grease film has developed. The brushes should be checked for wear and, of course, for spring tension, and the shunts or pigtails should not be broken or frayed. The field coils in synchronous motors should be examined to see that there are no turns working loose and that the coils are tight on the pole pieces, for if they become loose they will chatter because of vibration and may develop grounds or short circuits.

An occasional check should be made of d-c. motors and exciters for alignment, vibration and cleanliness. Commutators should be kept in good condition and brushes checked for wear and spring tension. The shunts should be examined periodically.

Frequently commutators are sanded when it is not necessary, thus contributing to motor failure because dust and abrasive material develop under the brushes. Commutators may have a rather dark chocolate color, which is in no way detrimental, as a bright copper appearance is not necessary. When a commutator shows signs of sparking, this may be caused not by dirt but by some misadjustment which should be taken care of in the machine rather than by sanding the commutator.

The air gap of a motor should be checked every six months to prevent excessive wear in the bearings. It is important to keep the oil level at the right height, for if it is too low the bearing may burn out and if it is too high the oil may be carried along the shaft and get into the windings. This condition is very undesirable, as oil will deteriorate most insulations and will help in accumulating dust.

More ball bearings are ruined by overgreasing than by being operated with insufficient grease. When they are greased, the drain plug should be removed while running the motor and grease should be forced into the top of the bearing until all the old discolored grease has been extruded from the bottom, after which no more grease should be added. When the grease stops coming out of the bottom drain, it can be plugged and the bearing put into regular operation.

Every two years the motor should be disassembled and the windings thoroughly cleaned, dried and sprayed with a good insulating varnish. The motor should then be reassembled, taking care to see that the end bells line up and that the current between the rotor and stator is correct.

It must be realized that a motor does not last forever, and that, no matter how well a machine is maintained, there will come a time when a failure is more or less imminent. Therefore, thought must be given to rewinding motors which are more than 20 years old—the normal life of a piece of electrical equipment as figured by the underwriters of the insurance companies.

A megger test will give a fair idea of the general insulation condition, but there is no assurance that a failure might not occur. Deterioration of in-

sulation will show over the years, however, if such tests are run every six months and the results plotted. A high-potential test is the only real check on the quality of the ground insulation, but few can risk it since a failure would mean shutting down the machine without preparation to take care of the load during the repair period. Furthermore, the coils may have deteriorated to a point where there is danger of a short circuit occurring even though the machine does not go to ground. The best guarantee of continuous service would be to have the motor rewound after 20 or 25 years of operation.

The mechanical parts of a motor should wear almost indefinitely if the bearings are kept in good condition and if the machine has not been subject to extreme vibration. The bearings can be rebabbitted—or, if ball bearings, can be replaced when worn out—and today shafts can be metallized and brought up to standard so that they operate almost as well as the original shaft.

Safety Precautions

The matter of safety should be considered at all times. Workmen should wear rubber gloves when handling live circuits and should stand on a dry board even when dealing with lower voltages. No work should be done on any piece of equipment unless the line is known to be dead and the switch is locked out so that the current cannot be turned on accidentally. Every member of the maintenance crew should be familiar with the principles of artificial respiration and resuscitation.

This Month's Cover

Provided by the U.S. Bureau of Reclamation's B. D. Glaha, Chief Photographer, via Carl M. Hoskinson of the Sacramento Div. of Water, this month's picture gives an overall view of Shasta Dam, powerhouse and reservoir, with snowcapped Mt. Shasta kibitzing over the shoulder of the intervening sierra. The reservoir, located about 20 miles north of Redding in northern California, has a capacity of approximately 4,250,000 acre-ft. and is used as a primary regulator of Sacramento River flow through storage above the dam.

A little large to be visualized as "a stitch in time," Shasta Dam may yet save the proverbial "nine" if a quick melt lets loose an overdose of the record snow in the western mountains. As a matter of fact, in view of the extraordinary distribution of this winter's snowfall, it will be well if all riverine water works men in the snow-surfeited West and Midwest take positive action now to protect their plants and service against the fearsome consequences of a sudden thaw. Only by proper preparation can this spring's certainty of high water be kept in hand and the threat of flood catastrophe reduced.

As far as we're concerned, no more convincing evidence of the imminent danger of the situation is required than the knowledge that flood-wise Tom Skinker, Commissioner of the St. Louis Water Div., has already put his house in order to combat flood waters higher by 2 ft. than the record inundation of 1947. So, though time won't permit a Shasta of your own, some positive precautions are clearly indicated.

Effect of Water Quality on Ornamental Plants

By Harold E. Pearson

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by Harold E. Pearson, Research Chemist, Metropolitan Water Dist. of Southern California, La Verne, Calif.

CRITERIA for determining the quality of water are dependent upon the major use of the water, be it domestic, agricultural or industrial. For municipal supplies, first consideration must naturally be given to those characteristics of the water which determine its suitability for human consumption. Of almost equal importance are those characteristics which contribute to the convenience of the consumer. Thus, since hard waters are less desirable than soft for the cleansing operations in the home, an increasing number of municipal softening plants will probably be built. The home garden with its various ornamental plantings also brings much pleasure and satisfaction to the city dweller. In the arid West, where these plants must be irrigated with the municipal water supply for several months each year, water quality is of great importance to the homeowner.

Studies were initiated in 1942 by the Metropolitan Water Dist. of Southern California to determine the effects of natural and softened Colorado River water on a number of popular ornamental plants grown in this area. Observations of plant response to waters used in other Southern California communities have been made to supplement these studies. At the outset, it was assumed by the district that there were some differences in the viewpoints of the agricultural producer and the home gardener. In agricultural operations the profit motive is paramount, but the home gardener grows plants to beautify his property. Many exotic plants are seen in home gardens because people are willing to go to some expense to adapt their cultural practices to suit the needs of the plant. Since the home gardener is willing to purchase special fertilizers, peat and other aids to produce the plants he enjoys growing, the use of corrective measures to adapt his cultural practices to water quality is not altogether foreign to him. Indeed, for many years the growers of acid-loving plants have been neutralizing the effects of alkaline waters by the use of various acidifying agents like sulfur, alum and ferrous sulfate.

The objectives of this paper are: [1] to discuss those characteristics of a water which may have an unfavorable influence on plant growth and [2] to suggest practical means of ameliorating these effects for certain waters. If two or more waters are available, knowledge of the first point may be useful in selecting the more desirable water for growing plants. As the increasing population in urban areas creates greater demands on existing water supplies and forces the utilization of other water resources, it is often necessary to use waters which may not be ideally

suited for particular purposes. The suggestions made herein may enable the water works profession to understand and assist the consumer with certain problems relating to the irrigation of ornamental plants.

Waters suitable for domestic uses usually do not contain dissolved salines in amounts likely to be directly harmful to plant growth. It is the accumulation of soluble salts in the soil after prolonged irrigation which causes trouble. Following irrigation, most of the water is lost by evaporation from the surface soil and by transpiration from the plant, giving rise to higher saline concentrations in the soil *unless sufficient water is added periodically to move these salts below the root zone.* In addition to the possibility of salt accumulations, certain waters may produce physical and chemical changes in the soil which affect plant growth. Those soil changes which sometimes follow the use of an irrigation water may occur rather slowly because of the reservoir-like nature of the soil *in situ.* For this reason most of the experimental work with ornamental plants has been done with plants in pots or other small containers.

TABLE 1

Analysis of Irrigation Waters

Item	Local Well	Colorado R. Aqueduct, 1942–44				1947–48 Normal Treatment
		Natural	Degree of Softening			
			Partial	Normal	Complete	
	ppm.					
Silica (SiO_2)	9	8	8	9	9	13.4
Calcium (Ca)	21	94	60	25	1	31
Magnesium (Mg)	8	34	22	10	2	13.5
Sodium & potassium (Na + K)	69	123	186	250	292	197
Carbonate (CO_3)	0	0	0	4	0	16
Bicarbonate (HCO_3)	153	144	143	140	144	66
Sulfate (SO_4)	54	367	369	369	369	328
Chloride (Cl)	38	100	101	101	101	99
Boron (B)		0.1	0.1	0.1	0.1	0.1
Total dissolved solids	276	798	818	838	846	732
Total hardness as $CaCO_3$	85	375	241	103	11	133
"Per cent sodium"	64	42	63	84	98	76
pH	7.1	8.2	8.3	8.5	8.0	9.1
Electrical conductivity—*mho* $\times 10^6$	380	1.260		1,400	1,420	1,170

Potted Plants

Analyses of the waters used for irrigation in these investigations are shown in Table 1. The water con-

taining only 276 ppm. of total dissolved solids was used as a standard for comparison of plant growth with the more saline waters. The normal treatment of aqueduct water at the time of these tests, 1942–44, produced a water having a hardness of 100 ppm. as $CaCO_3$ with sodium accounting for 84 per cent of the total cations present. Improvement in the quality of the natural water and a slight modification in the hardness of the treated water have resulted in the lowering of the sodium percentage to 76–77. The complete analysis of the present water is shown in the last column of Table 1.

The response of Rex begonia, fuchsia, boxwood, chrysanthemum and camellia plants to water quality after several months of irrigation is shown in Table 2. The foliage of the Rex begonia was found to be subject to injury when sprinkled with the water containing only 276 ppm. of total salts. Since the data in the table are based on the dry weight of the foliage produced, the yield does not reflect differences in the quality and general appearance of the plants. Sprinkling of the Rex begonia foliage with the natural and treated Colorado River water caused more marked burning of the tips and margins of the leaves than sprinkling with the less saline water. As shown elsewhere (1), this injury caused by sprinkling seemed to be correlated with the absorption of a greater amount of sodium, chloride and sulfate ions by the leaves. The tuberous and fibrous begonias and many rhizomatous types have been observed to be much less sensitive to natural and treated Colorado River water than the Rex begonia.

TABLE 2

Effect of Water Quality on Plant Growth

Plant	Irrigation Period mo.	Local Well*	Colorado R. Aqueduct*			
			Natural Untreated	Degree of Softening		
				Partial	Normal	Complete
		Plant Growth Index†				
Begonia, Rex, flooded	7	100	60		53	
Begonia, Rex, sprinkled	7	56	44		54	
Fuchsia, Jupiter	6	100	90	90	90	75
Boxwood	12	100	98	99	101	87
Chrysanthemum	5	100	92	92	89	85
Camellia, Pink Perfection	12	100	84		88	
Camellia, Pink Perfection	24	100	78		58	

* For analysis of water see Table 1.
† Based on growth with local well water equal to 100.

The growth of fuchsia, boxwood and chrysanthemum was not markedly affected by the different waters. The waters having a high sodium percentage, 84 and 98, although not reducing the yields markedly, produced plants with a more compact, bushy habit than the waters containing more calcium and magnesium. The 84 per cent sodium water did not affect the growth of the

camellia much during the first year, but the development of plants left in the same 6-in. pots for two years was depressed more noticeably. The camellia did not show any visible symptoms of saline injury during the two-year period. Therefore, since the hard water of the same total salt content caused little growth depression, it was apparent that growth was retarded by the low calcium status of the soil following prolonged irrigation with the softened high-sodium water.

Observations of azaleas after irrigation with waters containing approximately 500 ppm. of dissolved solids indicate that some varieties may be injured whereas others will remain normal in appearance. Those azaleas showing greater tolerance to soil salinity, particularly varieties of *A. indica,* may not grow as vigorously when irrigated with waters containing more than 500 ppm. of total salts as with low-saline waters. The epiphytic orchids also exhibit a low tolerance to soil salinity.

TABLE 3

Relative Tolerance to Salinity

Plant	Measurement	Avg. Relative Yield*
Sweet Peas	Dry wt.	81
Ageratum	Dry wt.	43
Marigold	Dry wt.	51
Calendula	Fresh wt.	58
Zinnia	Fresh wt.	86

* Control base nutrient equals 100.

For an accurate measurement of the relative tolerance of various plant species to salinity, it is necessary to resort to sand culture techniques for controlling the salt concentration of the substrate. In addition, the plants should be produced under the same environmental conditions, because such factors as temperature and relative humidity of the air and light intensity also influence plant growth. Several annual flowering plants were placed in tanks containing sand which could be automatically irrigated with culture solutions three times daily. Table 3 shows yields obtained in a culture containing 75 milliequivalents (me.) per liter of sulfate and 25 me. per liter of chloride plus basal nutrient solution. The relative yield indicates the dry weight of replicate plants grown with the saline culture, expressed as a percentage of the weight of control plants watered with the base nutrient.

Although the quantities of salts present in these solution cultures were about 7,000 ppm. and considerably higher than in any domestic water supply, the data emphasize the need for periodic leaching to move below the root zone those salts which may be contained in the water.

TABLE 4

Changes in Soil Salinity

Depth *ft.*	Electrical Conductivity* *mho* $\times 10^6$ May 1942	March 1947	Aug. 1947
0–1	244	464	441
1–2	183	437	437
2–3	213	501	314
3–4	200	675	347

* 1:2 soil-water extract.

In the East, where rainfall is sufficient to accomplish this leaching, water quality for plants is probably of interest only to nurserymen growing plants under glass. In Oklahoma, Wall and Cross (2) found that waters containing approximately 200 ppm. of total salts are excellent for greenhouse use and those containing 500 ppm. of total dissolved solids are likely to cause reduced growth only with the more salt-sensitive plants or under unfavorable conditions of temperature, light and hu-

midity. They also state that waters containing 1,000 ppm. of total salts can generally be used satisfactorily, but the kinds of salts present and their quantities must be considered. In this study the waters containing approximately 800 ppm. of total salts were satisfactory for growing some types of begonia, fuchsia, camellia, boxwood and chrysanthemum, but they caused trouble with Rex begonias and some azalea species. The high-sodium waters were less desirable than high-calcium waters.

Effects on Soils

The effects of high-sodium waters on soils have been discussed by Magistad (3) and others (4, 5). It is almost impossible to define the permissible limits for the composition of an irrigation water (4) because sandy soils react differently from clayey soils, and soils high in organic matter do not behave like those of low organic content. After noting certain exceptions, Magistad and Christiansen (5) state that waters containing more than 75 per cent sodium are likely to affect soil permeability and structure seriously after prolonged use. The changes in soil characteristics following irrigation with the softened Colorado River water containing 77–84 per cent sodium are being observed in a field experiment initiated by the district in 1942 in cooperation with the University of California. Soil tests made in 1947 after six irrigation seasons (6) showed some increase in the percentage of sodium on the soil colloids, from 3 per cent originally to 6.5, and some depletion of the calcium reserves in the surface soil. Measurements of the rate of water movement into the soil (infiltration rate) indicate that physical changes in the soil are beginning to appear, but they are not very marked yet.

While corrective methods are available to ameliorate the influence of high-sodium waters on soils, their effectiveness is limited by the low solubility of those calcium compounds which can be added to the soil without injury to the plants. The softening of water removes calcium and magnesium and thereby increases the percentage of sodium in the treated water. In the arid West, especially, the water works profession should give serious consideration to the effect of high-sodium waters on soils and plants in the home garden when determining the degree of softening for municipal supplies. Local soil conditions and the total salinity of the water should be considered in deciding upon the most desirable hardness for the finished water.

Corrective Measures

If the composition of the water supply has a tendency to affect plant growth, the dissemination of information on good cultural practices to offset these effects may be desirable. The Metropolitan Water Dist. has issued two printed circulars to assist gardeners with their cultural problems; one contains suggestions for soil conditioning and irrigation methods and the other covers methods for growing acid-loving plants.

There is a need for excellent soil drainage and the use of sufficient irrigation water to cause approximately 5 to 10 per cent of it to drain below the root zone for those waters containing more than 500 ppm. of total salts or 150 ppm. of chloride. To move the salts below the root zone, one should irrigate more heavily and not so often. In addition to its favorable influence on salt removal, this practice causes better root distribution than frequent light sprinkling. With some soils and waters, suffi-

cient leaching may be attained by a single heavy irrigation at the beginning of the growing season. In certain localities, winter rainfall may accomplish this leaching. Data in Table 4 for the salt content of a heavy clay soil irrigated with softened Colorado River water since 1942 show that irrigation methods and winter rainfall averaging 14 in. annually have prevented an excessive accumulation of salts. The soil for potted plants should be leached more frequently than that in the garden because of inefficient water usage. Thorough leaching at six- to eight-week intervals during the irrigation season should be sufficient for waters containing 500 to 1,000 ppm. total salts.

Plants have greater difficulty in absorbing moisture from slightly saline soils than from those which are nonsaline. Since the plant can absorb moisture more readily from a moist soil than a dry one and since salts make the soil (physiologically) drier, it is necessary to keep the soil as moist as possible without injury to the plant when irrigating with moderately saline waters.

The use of considerable organic matter in the soil is advisable to increase its moisture-holding capacity and maintain its fertility. Under a regime of periodic leaching to remove salts from the feeding zone of the roots, there is some loss of the soluble components of fertilizers. In the course of these investigations, slowly available nitrogen sources, such as cottonseed meal, bone meal, fish meal and legume straw, have been observed to maintain soil fertility more easily than soluble fertilizers.

The maintenance of adequate calcium reserves for supplying the nutritional requirements of the plant and preventing soil dispersion is desirable when irrigating with high-sodium waters. Even the acid-loving plants absorb considerable amounts of calcium (1). Of several amendments tested, gypsum, calcium sulfate, and superphosphate were found to be the most beneficial to plant growth. Only a few plants are sensitive to saturated solutions of gypsum, making it the safest amendment to use.

Waters containing 200 ppm. of bicarbonate will seldom cause difficulties except for certain acid-loving plants, according to Wall and Cross (2). Waters containing more than 500 ppm. bicarbonate probably should be neutralized for general use, either by adding sulfuric acid to the water or by applying sulfur to the soil. An acid root environment for acid-loving plants can be maintained by the use of one-third by volume of acid peat moss in the soil mixture. Subsequent feeding with a mixture of cottonseed meal and sulfur (10:1 by volume) will continue to keep the soil acid if some leaching is practiced. The above methods are suitable for neutralizing hard calcium bicarbonate water. If sodium constitutes a major portion of the cations, as in soft alkaline waters, the use of gypsum, discussed in the previous paragraph, is more likely to improve soil conditions than simple acidification.

In the commercial production of highly valuable plants, the treatment of a water supply to adapt it to the needs of the plant is often feasible. The demineralization of waters by ion exchange is practical for orchid culture. A modification of the electrolytic process described by Briggs (7) has been used to reduce the salinity of a water containing 500–700 ppm. down to 300 ppm. for orchid culture, with a marked improvement in plant growth.

For the amateur grower, the methods discussed previously have given satisfactory results with the normally softened Colorado River water, and only the growers of highly prized plants are likely to resort to these special techniques of water conditioning. In studying the idea of a household "hardener" instead of a "softener" for irrigating plants, as suggested by Magistad (3), it was discovered that the low efficiency of the reverse cycle with zeolite reduced the sodium percentage of Colorado River water only from 84 to 62. A satisfactory exchange process for removing the sodium ion without resorting to complete demineralization is first to pass the water through a hydrogen exchanger to remove the major part of the calcium, magnesium and sodium, and then to pass the acid water through a bed of marble chips to neutralize the excess acidity. In high-carbonate waters, neutralization of excess acidity can be accomplished by blending the proper amount of bypassed untreated water. Waters of low alkalinity may be neutralized by the marble-chip method or by adding a controlled dosage of lime to convert the sulfate and chloride ions to the calcium salt.

Summary

The effects of water quality on plant growth have been studied for natural Colorado River water containing about 800 ppm. of dissolved salts and for the same water after various degrees of softening. Although increased softening did not markedly affect the weight yields of some ornamental plants, the growth habit was sometimes influenced by the high-sodium waters.

No specific limitations on water quality for growing ornamental plants are recommended, but ways of improving cultural conditions for plant growth with various kinds of water are discussed.

Acknowledgments

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References

1. Pearson, Harold E. Effect of Waters of Different Quality on Some Ornamental Plants. Proc. Amer. Soc. Hort. Sci. (*in press*).
2. Wall, R. F. & Cross, F. B. Greenhouse Studies of the Toxicities of Oklahoma Salt-contaminated Waters. Okla. Agric. Expt. Sta. Tech. Bul. T-20 (1943).
3. Magistad, O. C. The Use of Softened Colorado River Water for Home Gardens. Jour. A.W.W.A., **33**:883 (May 1941).
4. Kelley, W. P. Permissible Composition and Concentration of Irrigation Water. Proc. A.S.C.E., **66**:607 (1940).
5. Magistad, O. C. & Christiansen, J. E. Saline Soils, Their Nature and Management. Circular 707, U.S. Dept. of Agric., Washington, D.C. (1944).
6. Huberty, M. R. & Pearson, Harold E. Irrigation of Citrus Orchards with Waters of Different Chemical Characteristics—A Progress Report. Proc. Amer. Soc. Hort. Sci. (*in press*).
7. Briggs, R. E. Electrolytic Water Softening for Industrial Purposes. Proc. Eng. Soc. of Western Pa. 6th Wtr. Conf., p. 109 (1945).

The Value of Consumer Complaints

By Laurence L. Camy

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by Laurence L. Camy, Local Mgr., California Water Service Co., Los Angeles.

IT is of the utmost importance for water works management to keep well informed about consumer complaints of every description. Since the successful operation of a utility largely depends on consumer satisfaction, complaints are a yardstick by which management measures the degree of improvement in operations through the application of previously designed corrective measures directed toward the betterment of service.

All water distribution agencies are subject to consumer complaints. Generally speaking, the various types of complaints are common to all, ranging from service complaints concerning low pressure, as well as quality and high bills, to comments on personnel and miscellaneous complaints that may include any sort of fancied or real grievance by a dissatisfied consumer.

Management welcomes complaints as a means of verifying or revealing deficiencies that may or may not be under observation in regular surveys. For instance, low-pressure complaints may indicate inadequacies in transmission or distribution facilities that might not become apparent for a considerable length of time through periodic routine system flow and pressure studies.

Water Quality Complaints

Another type of complaint that is helpful to management consists of consumer reports on the presence of tastes and odors, dirt or sand in the water. It is, of course, taken for granted that all utilities adopt the necessary precautions to assure that the water served is bacteriologically safe for human consumption. Too often, however, system operators neglect to flush dead-end mains on schedule, or treatment equipment may not be functioning properly, particularly the automatic type that is serviced and checked once or twice daily. In such situations, a phone call serves notice of a condition that can be corrected immediately.

Complaints of dirty or sandy water are quite commonly received by most operators and can be a source of trouble in both gravity and well supplies. Storage basins and reservoirs accumulate deposits of silt and sand which are subject to disturbance and movement into the distribution system during periods of heavy draft or as a result of main breaks. Although incipient trouble can be foreseen and proper desilting or cleaning methods are provided for in a scheduled program, there is always the possibility of some unpredictable disturbance causing dirty water to enter the distribution system. This may result in complaints over a widespread area and may well be the first knowledge that management has of the condition, which generally can then be controlled promptly. Con-

sumers are cooperative when given a satisfactory explanation of the cause and probable duration of the disturbing condition, even if they are cooking or mixing the baby's formula.

Sand in the water is a source of many complaints, particularly in systems depending on well supplies. In spite of all efforts to develop a well completely by pumping to waste, at a rate much in excess of that predetermined for finished production, it is often found that a well will produce objectionable quantities of sand even after months of continuous use. Warning of this condition arises from complaints of low pressure and the cutting of washers in plumbing fixtures. If investigation reveals that the low-pressure condition is the result of stuck meters, the offending well can be easily identified, especially if the complaints are chronic. Should the well producing the sand pump directly into the distribution system, there is little chance that this condition will be observed until complaints are received. A systematic flushing program should be put into effect as a temporary remedy, pending a thorough study of a permanent solution.

High-Bill Complaints

High-bill complaints, by their very nature, are an indication of consumer dissatisfaction and have a direct bearing on the goodwill of the community toward the utility. The proper handling of these complaints is of such importance that management should keep a careful check on the cause and final disposition of each one. In a system employing the flat-rate method of billing, complaints are easily disposed of, as the answer to a complaint of this kind is usually a simple determination of whether or not the base rate has been properly applied. On the other hand, high bills in a metered system are usually reported by a comparatively few consumers. Most of these complaints can be anticipated by instructing meter readers to report unusual or abnormal consumptions at the time of reading. A field followup on this type of information reveals either a legitimate increase in normal consumption or a waste of water through leaky fixtures, which, when called to the consumer's attention, explains the reason for a high bill.

It is, of course, impossible to eliminate all high-bill complaints by following the above procedure, but the ones still received are comparatively minor in nature, the amount of the increase being small and usually easy to explain. Unless the consumer has been convinced that the bill in dispute is just, the complaint is often carried to the utilities commission, if the system is privately owned, or to some local government official, if it is a mutual or municipal operation.

Regardless of the type of agency involved, management should endeavor to keep complaints to regulatory or governmental bodies to an absolute minimum by proper first handling. Occasionally consumers contact the commission or government officials before making a complaint to the distributing agency and there is not always an opportunity to determine all the pertinent facts, as the consumer has had time to repair defective plumbing if that is the cause contributing to the high bill. Therefore, this type of complaint merits careful scrutiny by management.

Complaints About Personnel

Although complaints regarding personnel are rather infrequent, they should nevertheless receive prompt and careful attention. The goodwill earned through years of efficient and courteous service can be destroyed instantly by the improper selection of employees who are in direct contact with the public, either in person or by telephone.

In order to safeguard itself against complaints about personnel, it is one of management's duties to study the behavior patterns of employees. Then, when such a complaint is received, it should be possible to determine in advance if it is justified or if it is only a means of discrediting an employee for personal reasons.

Since it is impossible to monitor all employee contacts with the consuming public, management should take advantage of such complaints to learn whether its employees are courteous and tactful. Frequent complaints regarding an employee would indicate the necessity of a change to some other type of work. This is even more important when consideration is given to the fact that the utility business is monopolistic in nature. Hence, everything possible should be done to make the consumers feel that they are being treated just as fairly as though they were buying a highly competitive article from a merchant. Unfortunately, there is a tendency on the part of the employee to minimize a consumer's position because experience has shown that the average consumer, in making a complaint, is prone to exaggerate and distort the facts. This attitude by the employee may well lead to difficulties, because if he lacks proper understanding and sympathy for the consumer's point of view, a complete investigation may not be made, to the detriment of the consumer. Such a tendency can be detected by a review of completed complaint tags at regular intervals. A word of caution to the employee that the consumer is not always wrong is ordinarily all that is required to remedy the situation.

Construction and Repairs

A type of complaint that is not entirely confined to consumers is the reporting of backfill conditions on construction trenches as well as excavations for main repairs. These can be most annoying, as the water distributing agency strives for the cooperation and goodwill of officials in the street department, whose patience and ability to understand the utility's problem can become overstrained should the traveling public be needlessly inconvenienced. The fault may lie with either the water agency's own forces or a contractor's crew, but, regardless of who is at fault, it is management's responsibility to see that construction projects are conducted in such a manner as to offer the least inconvenience to property owners adjacent to the construction, as well as to motorists.

Combined with such complaints are problems of "no water," originating with consumers who for various reasons might not have been notified of a main shutdown affecting their service. In scheduling construction, one of the first steps should be to notify consumers within the area affected by the shutdown and include a fairly accurate estimate of the duration. Field crews often overlook one very important precautionary measure—that is, advising the office of the contemplated shutdown and its probable duration. Lack of such notification makes for an

awkward situation in the office as no intelligent reason can be given for the interruption, nor can any reasonable assurance be offered the consumer of an approximate time when service will be resumed.

Emergency shutdowns for major repairs can also cause a great deal of confusion if the crews making shutdowns neglect to notify the office. Ordinarily this type of complaint is difficult to handle in the office because few of the consumers involved have been able to observe that a repair is being made, and consequently they depend entirely on information obtained from the office when registering the complaint. The result is that vague and inadequate explanations may be made which do not serve to placate the consumer, who is justly entitled to complete information regarding the interruption of service.

Miscellaneous Complaints

The investigation of complaints of a miscellaneous nature may focus attention on certain conditions that require more than routine handling by the operating personnel. Examples of this type of complaint are: [1] an objection by a group of consumers to landscaping or color schemes used at pumping stations situated in a residential area; [2] reports of noise or vibration from consumers residing adjacent to a pumphouse; and [3] protests concerning the necessity of maintaining water works structures in residential areas. Such complaints require special attention from management, as the solution of these problems could entail large monetary expenditures, radical changes in operating procedures, or both. A frank discussion of the problem from management's viewpoint, and cooperation to the extent of making any necessary and reasonable improvements or corrections, usually takes care of the complaint to the mutual satisfaction of both parties.

No attempt has been made to offer solutions to the various problems briefly touched on in this paper, because it is recognized that most water works operators have had experience in dealing with them. Generally speaking, many phases of the operation of a water works are governed by a set of written instructions compiled by management and designed from knowledge gained through the solution of consumer complaints. Certain of these instructions are directed toward the betterment of service and if followed should eliminate many complaints. It should be stressed that the prompt acknowledgment and investigation of complaints does much to mollify a consumer's feelings and helps materially in solving difficulties.

Management should and does welcome complaints so that it can profit from past mistakes, thus reducing future complaints to a minimum and improving service to the consumer.

Ground Water in Wyoming

By Donald A. Warner

A paper presented on Sept. 17, 1948, at the Rocky Mountain Section Meeting, Cheyenne, Wyo., by Donald A. Warner, Ground Water Geologist, State Engineer's Office, Cheyenne, Wyo.

IN recent years it has become obvious that, if Wyoming is going to continue its physical and economic growth, ground water must be drawn on increasingly, and for more than just domestic and stock water. Accordingly, many towns and municipalities have turned either wholly or in part to the use of underground water. At present roughly 75 per cent of the municipal water supplies in the state are dependent in some way upon ground water. The city of Laramie derives its supply wholly from wells and springs, and Cheyenne obtains approximately 25 per cent of its supply from wells. The largest single use of ground water in the state, however, is for irrigating about 13,000 acres.

Investigations and Surveys

Near the turn of the century several reconnaissance surveys were made by the U.S. Geological Survey and generalized data were gathered on the occurrence of ground water. It was not until 1923, however, that any truly competent work was done in the state, and then only on a limited scale in the Lodgepole Valley just east of Cheyenne. As a result of the increased use of ground water and the need for obtaining more detailed information about its occurrence, intensive studies were undertaken late in 1940 at the instigation of the State Engineer. These investigations were of a cooperative nature, originally handled by the Wyoming State Planning and Water Conservation Board and the U.S. Geological Survey but now conducted by the State Engineer and the U.S. Geological Survey.

The first work was done in the southeastern corner of Wyoming in the area around Pine Bluffs, where ground water is being developed intensively for irrigation. This work has been completed and a detailed report is being prepared. By the middle of 1942 the cities of Cheyenne and Laramie were also cooperating in ground water investigations with the U.S. Geological Survey through the Planning and Water Conservation Board, in the hope that additional water for municipal use could be located and developed. Rather comprehensive reports have been completed by the cooperating agencies showing the results of these investigations.

During this period several small municipal underground water supply investigations have also been undertaken throughout the state. Only recently such an investigation was completed at the town of Newcastle, in northeastern Wyoming near the Black Hills. These small investigations are undertaken at the request of various towns by the U.S. Geological Survey and are financed either by the Wyoming State Geological Survey or are made a part of the regular program carried on

through the State Engineer's Office. Basically the interest of the State Engineer's Office in ground water is in the field of irrigation. It is felt, however, that any assistance afforded the municipalities in the realm of water supply is well within its sphere of activity.

In addition to the ground water activities previously outlined, the federal government has itself been carrying on various investigations throughout the state under a part of the program of the U.S. Bureau of Reclamation for the entire Rocky Mountain area.

It is hoped that eventually underground water studies will be made over the entire state and that knowledge of its total ground water resources will be available.

Ground Water Law

It is apparent that the logical corollary to the investigation of the state's ground water supplies is the problem of regulating and conserving this important natural resource so that it does not become depleted and result in costly litigation, serious quarrels and a disastrous lowering of the water table, as has happened in some neighboring states. With these views in mind the State Engineer presented to the Wyoming legislature in 1941 a comprehensive code designed to control and conserve the ground water resources of the state. Because it was found to be impossible to get this bill introduced in the legislature, the proposed code was drastically cut down and a revised bill finally was introduced in the House. Its main provisions are given below:

1. All underground waters not developed or used for beneficial purposes at the time of the enactment of the code were declared state property and were to be subject to appropriation.

2. The beneficial use of underground water, if exercised during at least one of the last five years preceding the date of the act and not heretofore abandoned, was declared a vested right.

3. Reasonable economic beneficial use was to be the basis, the measure and the limit of the right to use underground water at all times.

4. The use of water for stock and domestic purposes on an individual farm, and for lawns and gardens where the area to be irrigated did not exceed ½ acre, did not require the filing of a claim.

5. In order that all parties might be protected in their lawful rights, every person claiming any interest in any means of securing underground water was to file a statement of claim with the State Engineer.

6. Rights to the beneficial use of underground water were to be obtained through the same procedure as surface water rights, and no rights were to be issued where the development had passed beyond the safe yield of the aquifer.

7. The State Engineer was directed to determine the capacities of the various aquifers throughout the state.

Although the bill as introduced was inadequate, it at least covered the main problems encountered in ground water legislation. After failing to pass in 1941 and 1943, a modified version of the bill was finally enacted in 1945. It contained the sections on vested rights and on beneficial use as the basis of the right, as well as the exemptions originally requested, which have previously been outlined. The major change in the bill was that the ground waters in the state were declared a matter of public interest rather than state property. The law was expanded by the 1947 legislature to include the setting up of regulatory machinery and

means were provided for getting all the pertinent data on the claimed use of ground water recorded in the State Engineer's Office. The 1949 legislature will be asked to extend the time for filing statements of claim to ground water use from December 31, 1947, to December 31, 1950. Even as the law now stands it is deficient in some respects, and it will have to be expanded and clarified before it will be possible to protect the rights of the users adequately and to conserve the ground water resources of the state for the benefit of the state as a whole. The ultimate aim is to have enough data available to deal with the problem of ground water regulation and conservation in a manner as comprehensive as that employed for the surface waters of the state.

Development of Resources

The future development of the ground water resources of Wyoming is very promising. In the past the main use of ground water has been for irrigation. During the preceding decade the consumption of ground water for this use has more than tripled, and each year an increasing amount of new land is brought under ground water irrigation. In addition, many surface water irrigators are turning to ground water for supplemental use, particularly in those areas where sufficient surface water is not available throughout the irrigation season. Although the main ground water irrigation area, which is in the southeastern corner of the state, is highly developed at the present time, it can stand further development without depleting the aquifer. The other large ground water irrigation area in Wyoming is in the North Platte Valley in Goshen County, where the ground water is used primarily as a supplemental supply. It is felt, however, that much additional subsurface water can be made available for bringing new lands under irrigation in this area, as well as in many others throughout the state where the geologic and hydrologic conditions appear favorable. Specifically, the Sweetwater country west of Casper and the Powder River Basin in the northeastern portion of the state and the Star Valley area in the extreme western part of the state are potential ground water irrigation areas. The principal difficulty in developing ground water for irrigation in Wyoming is that much of the state is covered with relatively impermeable Tertiary sediments. Generally speaking, prospecting is thereby limited to those areas adjacent to rivers, where it may be possible to tap large sand and gravel aquifers.

It is becoming increasingly apparent that if Wyoming is to continue its population growth many of the towns must turn more and more to underground water for their municipal supply. As has been stated previously, about 75 per cent develop their water from subsurface sources ranging all the way from infiltration galleries to very deep wells. A few of the larger cities developing underground water are Casper, Cheyenne, Gillette, Laramie, Rawlins and Wheatland. Casper and Cheyenne depend only in part on ground water, but the other four rely entirely upon such water, either from wells or from natural springs.

In Wyoming, ground water usually provides a better municipal supply than surface water. Ground water is relatively constant in its chemical character and, though it may often be termed hard, the only treatment usually deemed necessary is chlorination. For this reason, municipal water works find the use of ground water economical. It is not intended, of course, to give the impres-

sion that ground water is the complete answer to the problem of the expansion of the various towns and cities in Wyoming.

The conditions necessary for an adequate ground water supply are determined by both geologic and hydrologic factors. The primary geologic requirement is the presence of a permeable aquifer, which may be a sandstone, limestone or gravel bed. Shales and clays generally have too low a permeability to produce water in large quantities. The hydrological consideration involved is the necessity for recharging the aquifer. It is an indisputable fact that for each gallon of water withdrawn from an aquifer another gallon must be returned or eventually the aquifer will become depleted. The sources of recharge are principally rainfall penetration or seepage from surface streams into the aquifer. As a crude generalization, it may be stated that if these two conditions can be met it is then simply an engineering problem to get the water to the surface.

But the Tertiary clays and shales with intercalated sandstone beds widely present in Wyoming are normally poor aquifers. Therefore, in order to develop a ground water source it is necessary to look deeper into the earth for the water. To do this in the most economical way it is advisable to call upon trained ground water technicians who can at least point out all the possibilities and often prevent much useless drilling. Within the past two years Glendo, Ranchester, Kaycee and Newcastle have called upon the U.S. Geological Survey for this service, and other towns are expected to follow suit.

Although the future for ground water in Wyoming appears very promising, a long road must still be traveled before this resource will be developed to its greatest potential.

Transportation Tax Exemption

The Revenue Act of 1943, effective June 1, 1944, continues in effect the exemption from payment of the transportation tax by states or their political subdivisions. This means that water department employees may purchase tickets for any form of public transportation (where the tax applies; i.e., train, airplane, bus) without paying the 15 per cent federal tax, if the following conditions are met:

1. The travel must be recognized as official by the water department or city executive.
2. The official nature of the travel is, or will later be, evidenced by the payment (or reimbursement) of the amount paid for transportation.
3. The purchaser of the ticket or tickets presents to the agent of the common carrier a properly executed copy of Treasury Department form 731.

Copies of form 731 are obtainable from the various offices of the U.S. Internal Revenue Department. The completed form must be presented to the agent of the carrier when the ticket is purchased.

More complete information may be found in the JOURNAL for September 1944, Vol. 36, page 1005.

Report of the Audit of Association Funds

For the Year Ending December 31, 1948

To the Members of the American Water Works Association:

The By-Laws require that the Secretary shall have an annual audit made of the books of the Association.

The records for 1948 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Reference may be made to past audits which appeared in the JOURNAL as follows: pp. 520–25, March 1938; pp. 570–74, March 1939; pp. 516–20, March 1940; pp. 774–78, April 1941; pp. 426–30, March 1942; pp. 338–42, March 1943; pp. 359–63, March 1944; pp. 317–21, March 1945; pp. 386–90, March 1946; pp. 273–78, March 1947; and pp. 345–50, March 1948.

Respectfully submitted,

HARRY E. JORDAN
Secretary

January 27, 1949

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1948, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet and statements of income and surplus present fairly the position of the American Water Works Association at December 31, 1948, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & CO.
Certified Public Accountants

EXHIBIT A—Balance Sheet

December 31, 1948

Assets

Cash in Banks and on Hand		$24,904.53*
Accounts Receivable:		
Advertising	$5,631.63	
Reprints	309.37	
Sundry specifications	297.89	
Other	337.50	6,576.39
Membership Dues		513.50
Accrued Interest on Bonds		484.22
Inventories:		
Paper stock	7,242.63	
Type metal	837.80	
Cumulative Index (256 copies)	307.20	
Manual of Water Works Accounting (13 copies)	18.85	
Quest for Pure Water—Baker	2,024.00	
Sundry specifications, including advance charges relating to publications	3,003.15	
Back issues—Journals, Vol. 1–40, inclusive (31,039 copies)	—†	
Back issues—Proceedings, 1881–1913, inclusive (263 copies)	—†	13,433.63
Office Equipment (less depreciation)		4,841.94
Investments at Cost (Schedule 1)*		114,396.36
Deferred Convention Expense		399.55
Deposit		425.00
Total Assets		$165,975.12

Liabilities and Surplus

Accounts Payable		$ 227.63
Membership Dues—Advance Payments		11,735.47
Deferred Income:		
Subscriptions to Journal	$2,396.70	
Advertising	96.00	2,492.70
Reserve for Award Fund (McCord)		53.02
Surplus, per Exhibit C		151,466.30
Total Liabilities and Surplus		$165,975.12

* Effective December 31, 1948, the Association adopted a pension system. It is proposed to set aside, out of working assets, a fund of $50,000, the major portion of which will consist of securities carried as investments in the foregoing balance sheet. Any difference between $50,000 and the value of the securities transferred to the fund will be made up by a transfer of cash.

† Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication.

EXHIBIT A, SCHEDULE 1—INVESTMENTS

DECEMBER 31, 1948

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1948
Foreign Securities (see notes):				
Province of British Columbia	4½	$ 1,000.00	$ 1,000.00	$ 1,045.00*
Province of Ontario	4	1,000.00	732.50	1,115.00*
Canadian Victory Bonds	3	6,000.00	5,647.75	6,210.00†
Canadian Victory Bonds	3	2,000.00	2,000.00	2,070.00†
Hydro Electric Power Commission of Ontario	2¾	5,000.00	5,075.00	4,712.50†
United States Securities:				
City of Los Angeles	3½	2,000.00	2,241.11	2,312.50
U.S. Savings Bonds:				
Series D	2.9‡	10,000.00	7,500.00	9,800.00§
Series D	2.9‡	10,000.00	7,500.00	9,400.00§
Series G	2½	10,000.00	10,000.00	9,610.00§
Series G	2½	2,000.00	2,000.00	1,910.00§
Series G	2½	5,000.00	5,000.00	4,760.00§
Series G	2½	10,000.00	10,000.00	9,470.00§
Series G	2½	2,000.00	2,000.00	1,894.00§
Series G	2½	10,000.00	10,000.00	9,480.00§
Series G	2½	3,000.00	3,000.00	2,853.00§
Series G	2½	2,000.00	2,000.00	1,924.00§
Series G	2½	20,000.00	20,000.00	19,240.00§
Series G	2½	5,000.00	5,000.00	4,845.00§
Series G	2½	2,000.00	2,000.00	1,938.00§
Series G	2½	7,500.00	7,500.00	7,500.00‖
Excess of redemption value of United States Savings Bonds, Series D, over issue price			4,200.00	
			$114,396.36	$112,089.00

* These securities are payable in United States funds.
† The quoted market values of these securities are shown in Canadian funds. If these funds were converted into U.S. currency, such values would be decreased by approximately $975.00.
‡ Yield, if held to maturity.
§ Current redemption values pursuant to the terms of the bonds.
‖ Not redeemable until June 1, 1949.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES

FOR THE YEAR ENDED DECEMBER 31, 1948

Operating Income:

Annual dues	$72,125.75	
Advertising	58,731.78	
Subscriptions to Journal	5,096.26	
Convention registration fees	9,644.00	
Convention—other events	4,144.70	
Water and Sewage Works Manufacturers' Assn.	7,500.00	
Interest on investments	3,534.53	
John M. Goodell prize	75.00	
Miscellaneous interest income	36.84	
TOTAL OPERATING INCOME (carried forward)		$160,888.86

Total Operating Income (brought forward)			$160,888.86
Publication Income:			
Manual of Water Works Accounting	$ 214.60		
Reprints	3,917.12		
Cumulative Index	35.25		
Membership Certificates	59.60		
Proceedings and Journals	1,499.58		
Quest for Pure Water—Baker	2,012.00		
Water Works Retirement	384.00		
Sundry specifications	1,991.80		
Standard Methods of Water Analysis	340.00		
One-half of profit from sales of Standard Methods of Water Analysis	4,841.50		
Total Publication Income		$15,295.45	
Total Income (carried forward)			$176,184.31
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense	$ 5,719.66		
Stenographic expense	337.58		
Executive Committee meetings	298.68	$ 6,355.92	
Administrative Expenses:			
Rent	4,760.00		
Office supplies and services	8,394.81		
Membership promotion	966.66		
Pension and retirement fund	3,652.58		
Legal and accounting expenses	3,250.04		
Other expenses	622.62	21,646.71	
Administrative Salaries		47,973.64	
Committee Expense		823.03	
Division and Section Expenses:			
Section—membership allotment	13,209.43		
Section—official travel	4,052.49		
Section—general expense	563.56	17,825.48	
Journal:			
Printing	26,461.22		
Production	3,787.91		
Paper	8,683.63		
Directory	6,610.98		
Abstractors	216.44	45,760.18	
Convention:			
General	3,593.19		
Entertainment	6,946.13		
Management Committee	38.76	10,578.08	
Membership Dues in Other Associations		990.50	
John M. Goodell Prize		75.00	
Depreciation of Office Equipment		831.21	
Miscellaneous Expenses		299.44	
Total Operating Expenses (carried forward)		$153,159.19	

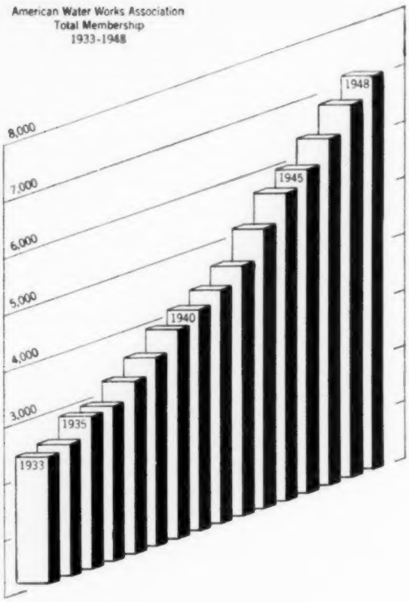
TOTAL INCOME (brought forward)			$176,184.31
TOTAL OPERATING EXPENSES (brought forward)		$153,159.19	
Cost of Publications Sold:			
Manual of Water Works Accounting	$ 112.43		
Reprints	3,569.23		
Cumulative Index	13.20		
Membership Certificates	37.72		
Proceedings and Journals	57.01		
Quest for Pure Water—Baker	2,668.43		
Fuller Award Certificates	8.62		
Water Works Retirement	358.51		
Standard Methods of Water Analysis	378.64		
Sundry specifications	1,505.56	8,709.35	
Public Relations		4,669.58	
TOTAL EXPENSES			166,538.12
Net Income for the Year (Transferred to Exhibit C)			$ 9,646.19

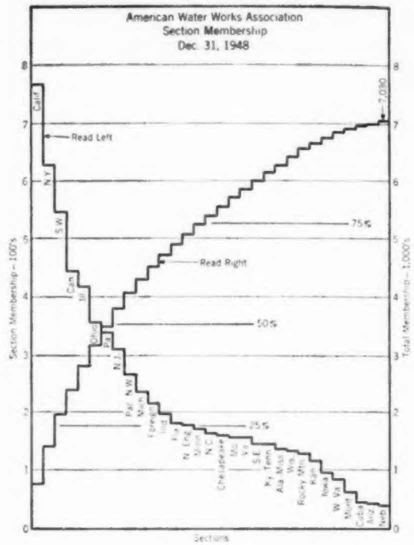
EXHIBIT C—SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1948

Balance, January 1, 1948	$141,820.11
Net income for the year, per Exhibit B	9,646.19
Balance, December 31, 1948, per Exhibit A	$151,466.30

Membership Statement—1948

	Active	Corporate	Associate	Honorary	Junior	Affiliate	Total
Total members, Jan. 1, 1948	5629	628	287	29	20	63	6656
Change in membership grade	2			2	−3	−1	
	5631	628	287	31	17	62	6656
Gains:							
New in 1948	714	84	24		19	6	847
Reinstated in 1948	69	6	6				81
	6414	718	317	31	36	68	7584
Losses:							
Resignations and deaths	172	16	14	2		3	207
Dropped for nonpayment	301	31	6		2	7	347
Total members, Dec. 31, 1948	5941	671	297	29	34	58	7030
Total members, Jan. 1, 1948	5629	628	287	29	20	63	6656
Net gain in 1948	312	43	10		14	−5	374





Comparative Statement—Gains and Losses—20-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of Dues	Gain or Loss	Total Members at End of Year
1929	314	25	118	130	+ 91	2547
1930	501	39	122	134	+285	2831
1931	203	22	123	216	−114	2717
1932	117	22	169	297	−327	2390
1933	168	56	159	234	−169	2221
1934	271	66	86	122	+129	2350
1935	565	42	85	190	+332	2682
1936	311	53	104	218	+ 42	2724
1937	515	86	122	139	+340	3064
1938	520	59	144	140	+295	3359
1939	578	64	112	179	+351	3710
1940	514	58	113	212	+247	3957
1941	480	92	116	236	+220	4177
1942	570	59	132	233	+264	4441
1943	769	88	130	198	+529	4970
1944	734	92	140	171	+515	5485
1945	543	56	111	235	+253	5738
1946	816	79	168	324	+403	6141
1947	933	74	143	349	+515	6656
1948	847	81	207	347	+374	7030

A.W.W.A. Pension System

This pension system for the staff employees of the Association, developed by a special committee of the Board of Directors, was approved by a Board letter ballot on Dec. 30, 1948, and confirmed by Board action on Jan. 16, 1949.

THIS Declaration made as of the thirty-first day of December, 1948, by The American Water Works Association, Inc., with business offices currently located at 500 Fifth Avenue, New York City, New York, hereinafter referred to as the "Employer," WITNESSETH:

WHEREAS, the Employer is a Corporation organized under the laws of the State of Illinois, for nonpecuniary profit with its object "the advancement of knowledge of the design, construction, operation and management of water works," and with its membership consisting of "persons interested in such matters"; and,

WHEREAS, the Employer has determined it to be in the interest of the Employer and of its Employees that a Pension System for such Employees be established,

NOW, THEREFORE, the Employer does, by this instrument, create and establish a Pension System for its Employees, to be known and designated as the "American Water Works Association Pension System," which shall be maintained and administered as follows:

Article I—Definitions

The following words and phrases, unless the context indicates otherwise, shall have the following respective meanings:

1. *Employee:* A person on the regular payroll of the Employer on or after the Effective Date, who receives a salary from the Employer for personal services, and whose duties require substantially full-time employment.

2. *Participating Employee:* An Employee included in the Pension System as provided in Article II.

3. *Retired Employee:* A Participating Employee who has retired on the pension allowance under the Pension System.

4. *Accredited Service:* The number of years before attainment of Normal Retirement Age during which any Employee was a Participating Employee, less the number of years, if any, for which a prior settlement was made under the terms of Article II, Paragraphs 4 and 5, and plus the number of years of Prior Service credited under the terms of Article II, Paragraph 3.

"Prior Service" shall mean the last continuous period of employment as an Employee immediately preceding the Effective Date of the Pension System. "Future Service" shall mean service rendered subsequent to the Effective Date of the Pension System by an Employee while he is a Participating Employee.

In computing the years of service for the purpose of determining benefits:

(a) A fractional part of a year comprising less than six months shall be ignored and a fractional part of a year comprising six months or more shall be considered a full year and the salary for such major fraction shall be extended to an annual basis to determine benefits applicable;

(b) A leave of absence for military service, including such additional pe-

riod after discharge as is consistent with national policy, or a leave of absence for other sufficient reasons, if granted by the Employer, shall not be considered to break continuity of employment and the period of such leave shall be included in the total years of Accredited Service if: (1) in the case of "Prior Service," the employee returned to the employment of the Employer on or prior to the expiration of such period; and (2) in the case of "Future Service," the Employee returns to the employment of the Employer on or prior to the expiration of such period and immediately resumes his status as a Participating Employee.

5. *Salary:* The annual amount of compensation paid to an Employee, before deductions, for personal services; and in the case of a leave of absence, the rate of salary in effect during the last calendar month preceding such leave shall be assumed to continue at the same rate for purposes of computing benefits.

6. *Pension:* A series of uniform monthly payments, each equal to one-twelfth of the annual pension, payable to the Retired Employee, the first payment to be made on the date of retirement, being in advance for such month, and the last payment to be made on the first of the month in which the death of the Retired Employee occurs.

7. *Actuarial Equivalent:* A benefit of equivalent value when computed at regular interest and mortality on the basis of the tables last adopted by the Administrative Committee.

8. *Normal Retirement Age:* The first of the calendar month following attainment of age 65 if a male and age 60 if a female while in the employ of the Employer.

9. The masculine pronoun whenever used shall include the feminine pronoun.

10. *Effective Date of the Pension System:* December 31, 1948.

11. *Anniversary Date of the Pension System:* The thirty-first day of December of any year following the Effective Date of the Pension System.

Article II—Participation in the Pension System

1. Any Employee on the Effective Date of the Pension System, and thereafter any Employee on the first Anniversary Date of the Pension System following his employment, shall be eligible to become a Participating Employee in the Pension System.

2. Once established, the eligibility of any Employee to become a Participating Employee shall be automatically renewed on each subsequent Anniversary Date of the Pension System throughout the remainder of any continuous period of regular employment.

3. To qualify for credit for Prior Service, any Employee on the Effective Date of the Pension System must within fifteen days thereafter apply for enrollment as a Participating Employee, as more fully set forth in Paragraph 7 of this Article II, and no credit for Prior Service will be granted if an Employee eligible upon the Effective Date of the Pension System does not then become a Participating Employee nor shall any credit be given for the years of service between the Effective Date of the Pension System and the date of enrollment for an Employee who defers becoming a Participating Employee.

4. A Participating Employee may terminate his participation in the Pension System upon any Anniversary Date of the Pension System by giving written notice of his desire to do so at least 30 days in advance. Upon such termination of participation, the Employee will have the right to request

that his pension account be settled upon the same basis as if he were terminating his service (Article VI), or he may leave his pension account in trust with the Employer with interest at 2 per cent, to be settled upon his retirement or termination of service.

5. An Employee who has terminated his participation in the Pension System and obtained settlement of his pension account may later again become a Participating Employee upon the same basis as any Employee who had never been a Participating Employee.

6. An Employee who has terminated his participation in the Pension System and left his pension account in trust with the Employer may later again become a Participating Employee, receiving full credit for this previous participation but no credit for the period during which his participation lapsed.

7. Every eligible Employee who wishes to become a Participating Employee shall before becoming a Participating Employee sign, within fifteen days after he becomes eligible, an application to become such a participant, in which he shall set forth his true age, with such documentary proof as may be required by the Employer, and in which he shall agree to the terms of the Pension System, including Employee contributions thereto.

Article III—Contributions

1. *Employee Contributions:* The Employer shall deduct 3 per cent of the salary of each Participating Employee from and after the date when such Employee became a Participating Employee, and such deductions shall constitute the contributions of the Employee.

2. *Employer Contributions:* The Employer shall within 90 days after the Effective Date of the Pension System transfer to the Administrative Committee $50,000 to partially fund the Prior Service cost.

In addition, the Employer, subject to the provisions of Article IX, Paragraph 6, shall make such contributions as are required, in addition to the contributions of the Employees, to meet the costs of maintaining the Pension System. The annual contributions of the Employer are to be equal to the normal cost for the year required to provide benefits not provided for by Employee contributions, plus the annual amount necessary to amortize the unfunded Prior Service cost over the ten years following the Effective Date of the Pension System, and plus the annual amount required to pay the costs of administering the Pension System.

Article IV—Retirement

A Participating Employee shall be retired and entitled to a Pension upon the happening of any one of the following:

1. Attainment of Normal Retirement Age.

2. Termination of employment by the Employer for total and permanent disability.

3. Termination of employment by agreement between the Employer and the Employee after 25 or more years of service.

4. A Participating Employee, by mutual agreement between the Employer and such Employee, may be continued in service by the Employer after attainment of Normal Retirement Age for a period not to exceed five years thereafter, but only the period of service up to Normal Retirement Age shall be used in computing benefits, and the pension payments shall be deferred until actual retirement. The Employee's contributions shall cease at Normal Retirement Age.

Provided, however, that any Employee who on the Effective Date is eligible to become a Participating Employee and is then over the age of 60 years may be continued in the employ of the Employer beyond this five-year additional period.

Article V—Pension

1. A Participating Employee upon retirement at Normal Retirement Age shall be entitled to an annual pension for life equal to $1\frac{3}{4}$ per cent of his salary earned during the period or periods during which he was a Participating Employee, plus $1\frac{3}{4}$ per cent of his salary as of the Effective Date of the Pension System multiplied by the number of years of Prior Service, if he qualified for such Prior Service credit under the terms of Article II, Paragraph 3.

2. A Participating Employee who retires under the provisions of Article IV, Paragraph 2 or 3, prior to attaining Normal Retirement Age shall be entitled to an annual pension for life, computed as in Paragraph 1 of this Article V, to begin at the Normal Retirement Age; or such Participating Employee may elect to receive at any time following his retirement, but prior to attaining Normal Retirement Age, the actuarial equivalent of such annual pension for life if received beginning at Normal Retirement Age.

If any Participating Employee retires due to disability, and he thereafter in the opinion of the Administrative Committee ceases to be totally and permanently disabled, his pension shall cease, and, if he returns to the employ of the Employer, any service credits accrued prior to his retirement shall be restored to him.

3. A Participating Employee who retired under the provisions of Article IV, Paragraph 4, after attaining Normal Retirement Age, shall be entitled to the actuarial equivalent of his annual pension for life, computed as in Paragraph 1 of this Article V, to begin on the date of his actual late retirement.

4. Any pension of less than $10.00 per month may be paid in a single lump-sum actuarial equivalent.

Article VI—Separation Benefits

1. Any Participating Employee, upon termination of employment, whether voluntary or involuntary, prior to retirement, with less than fifteen years of service, shall be entitled to a refund of his contributions plus interest thereon at 2 per cent per annum compounded annually to the date of termination of employment.

2. Any Participating Employee, upon termination of employment prior to retirement, with fifteen years or more of service, shall be entitled, as a separation benefit, to a choice between:

(a) A refund of his contributions plus interest at 2 per cent per annum compounded annually, or

(b) A paid-up annuity contract providing a straight life annuity after Normal Retirement Age and a refund of the cash value or purchase price, whichever is greater, on the death of such employee, or on the surrender of the contract, prior to the Normal Retirement Age of such employee, which annuity contract shall be purchased from an insurance company legally qualified in the State of New York, with a sum equal to the contributions of such Employee with interest plus that part of the Employer's contributions made for the benefit of such Employee which is vested. No part of the Employer's contributions shall be vested until such Employee has completed fifteen years of service. Upon the completion of fifteen years of service, a sum equal to 20 per cent of the contributions made by the Employer

theretofore shall be vested, and thereafter until attainment of Normal Retirement Age the percentage of vesting shall increase annually pro rata so as to reach 100 per cent at Normal Retirement Age. The amount of the Employer's contribution at any time shall be computed, for the purpose of this paragraph, as the amount which, with such Employee's contributions plus interest, would purchase a straight life annuity without refund for the amount of pension benefits then accrued to the credit of such Employee, beginning at Normal Retirement Age. Any balance of the contributions of the Employer that may have been made on account of such Employee shall revert to the Pension System.

The Employer shall hold such annuity policy until such Employee would have attained Normal Retirement Age, at which time it shall be delivered to him, except that such Employee may at any time elect to have such policy cancelled and take the benefits provided in Subparagraph (a) of this Paragraph 2, with interest computed to such date. Any proceeds of such annuity surrendered, in excess of the amount paid such Employee, shall revert to the Pension System.

Article VII—Guaranteed Refund of Employee Contributions Upon Death

Upon the death of a Participating Employee or a former Participating Employee for whom a pension account is held in trust by the Employer, or upon the death of a Retired Employee prior to his receipt of pension payments equal to the sum of all his Employee contributions with interest at 2 per cent per annum compounded annually to the date of retirement, the balance of his contributions plus interest to the date of retirement or death, whichever is earlier, shall be refunded. Such payment shall be made from the Pension System. Payment shall be made in a single sum as soon as is practicable after the filing of a claim with the Employer by the beneficiary or beneficiaries named to receive such refund in the last written instruction filed with the Employer by such Employee. If no beneficiary is so named, such refund shall be paid to the surviving spouse of such Employee, and if none to the estate of such Employee.

Article VIII—Death Benefit

Upon the death of a Participating Employee or a former Participating Employee for whom a pension account is held in trust by the Employer, or upon the death of a Retired Employee, a death benefit shall be payable. Such death benefit shall be computed on the basis of providing a sum of $50 for each year of Accredited Service under the Pension System, but shall in no case exceed $1,000. When and if an Employee becomes a Retired Employee before attaining Normal Retirement Age, the maximum amount of this death benefit shall automatically be reduced to $750; and when a Participating Employee, a former Participating Employee for whom a pension account is held in trust by the Employer, or a Retired Employee attains Normal Retirement Age, the maximum amount of this death benefit shall automatically be reduced to $500.

Article IX—Administration of Pension System

1. The general administration of the Pension System and the responsibility for carrying out the provisions thereof shall be placed in an Administrative Committee, the members of which shall be appointed from time to time by the Board of Directors of the Employer to

serve at the pleasure of such Board of Directors.

2. The Board of Directors may appoint either its Finance Committee or the Executive Committee as such Administrative Committee, if it so desires.

3. The members of the Administrative Committee shall elect a Chairman and a Secretary who may be, but need not be, one of the members of the Administrative Committee, and may employ counsel and such medical, accounting and actuarial services as they deem necessary in carrying out the provisions of the Pension System and may pay for such services from the Pension System if they are not paid by the Employer.

4. The Administrative Committee from time to time shall establish rules for the administration of the Pension System and may correct any defect or supply any omission or reconcile any inconsistency in such manner and to such extent as it shall deem expedient.

5. The Administrative Committee shall adopt from time to time service and mortality tables for use in all actuarial calculations required in connection with the Pension System, and it may accept the recommendations of its actuary concerning such tables and rates. Until changed by the Administrative Committee, 2 per cent compounded annually shall be the rate of interest used as the basis for all actuarial calculations.

6. It is the intention of the Employer to make contributions to the Pension System regularly each year but the Employer shall be under no legal obligation to continue to make such contributions. All contributions made to the Pension System together with the investments thereof and all income therefrom shall be held by the Administrative Committee, as from time to time constituted; such funds shall be invested only in investments which are legal for trust funds in the State of New York; such funds shall be used for the exclusive benefit of the Pension System, and all contributions of the Employer which are made to the Pension System shall be irrevocably made, subject only to the provision that if a surplus at any time exists due to erroneous actuarial calculations, such surplus may be returned to the general funds of the Association after all liability to Participating Employees and their beneficiaries has been satisfied.

7. This Pension System shall in no way be construed as a contract of employment between the Employer and any Employee, or as creating a right in any Employee to be continued in the employment of the Employer, or as a limitation on the right of the Employer to discharge any Employee with or without cause.

8. The Administrative Committee shall have the choice, at any time that pension payments are due and payable to a Retired Employee, to purchase, out of the funds of the Pension System, from an insurance company legally qualified in the State of New York, a straight life annuity without refund which will pay to such Employee his pension benefits, instead of paying such pension from the Pension System.

9. The Administrative Committee shall keep appropriate books and records for the Pension System, including minutes of its meetings and contribution accounts.

Article X—Liability of Employer

In the administration of the Pension System, neither the Employer nor its Board of Directors nor the Administrative Committee shall be liable for any act or failure to act not amounting to breach of good faith.

Article XI—Amendment

The Employer may amend this declaration from time to time and in all respects, provided only that no such amendment shall permit any part of the assets of the Pension System to be used for or diverted to any other purpose than the exclusive benefit of the Pension System, except as set forth in Paragraph 6 of Article IX concerning a surplus.

Article XII—Termination

The Employer reserves the right to terminate the Pension System at any time. Upon such termination the assets are to be liquidated by distributing to each Retired Employee receiving a pension direct from the Pension System, and to each Participating Employee, an amount equal to such Employee's contributions with interest at 2 per cent per annum compounded annually to the date of termination, less any pension payments made to such Employee plus such additional amount divided proportionately among such Employees as can be provided by the remaining assets to make the total payable to each Retired Employee the reserve set up for such Employee's pension, and to make the total payable to each Participating Employee the actuarial equivalent of the pension payable upon attainment of Normal Retirement Age, based on earnings and service to the date of termination.

In the event an annuity was purchased for a Retired Employee pursuant to Paragraph 8 of Article IX, such Employee upon termination shall be entitled to receive such paid-up annuity.

Article XIII—State or Federal Benefits

Nothing in this Pension System shall prevent any Participating Employee from receiving benefits from any social security, pension, annuity or retirement system heretofore or hereafter adopted by any state or the federal government, but in the event such Employee becomes covered by any such system, the pension benefits provided for him thereafter under this Pension System shall be reduced by the amount of the primary benefits provided for him, exclusive of widow and dependent benefits under any such system, or by the amount actuarially equivalent to such benefit. The amount of a Participating Employee's contribution to this Pension System shall be reduced by the amount of his contribution to such state or federal system.

The Employer may, but shall not be required to, take such action as in the exercise of its sole discretion it may determine necessary to secure the benefits of any such state or federal system for its Participating Employees or their dependents.

Article XIV—Miscellaneous Provisions

1. *Construction:* In the event a dispute shall arise over the proper construction to be given the meaning of any part of this Declaration, the decision of the Employer shall be final and binding upon all parties.

2. *Assignments:* Pensions provided in the Pension System shall not be subject to assignment, pledge, sale, garnishment or attachment and any such assignment, pledge sale, garnishment or attachment shall be null and void, and the Employer shall not be required to recognize any such assignment, pledge, sale, garnishment or attachment but in any such case may apply the pension for the benefit of the Retired Employee or his family as the Employer may think proper.

Report of the Committee on Water Works Practice

For the Year Ending December 31, 1948

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1948, submitted to the A.W.W.A. Board of Directors, Jan. 12, 1949, by Louis R. Howson, Chairman.

THIS report covers the activities of the various subcommittees of the Committee on Water Works Practice during the year 1949.

1. *Watershed Protection and Maintenance.* The function of this committee is primarily that of developing information rather than the assembly of standards or procedural documents. A section of the Annual Conference program for 1948 was set aside for the activities of this committee and, in connection with the newly organized Water Resources Division, a substantial amount of material is being prepared for the 1949 Conference.

2. *Deep Wells and Deep Well Pumps.* No modifications of the Standard Specifications for Deep Wells—4A.1–1946 have been proposed or are presently contemplated. The subsection of this committee which has had the responsibility for the development of specifications for deep well pumps should be relieved of its assignment in view of the hereinafter proposed joint activity of the A.W.W.A. and the A.S.M.E., looking toward the development of deep well pump standards.

3. *Steel Plate Pipe.* Revisions of the Standard Specifications for Electric Fusion Welded Steel Water Pipe of Sizes 30 in. and Over—7A.3–1940 and of the Standard Specifications for Steel Water Pipe of Sizes up to but not Including 30 in.—7A.4–1941–TR(1943) are officially approved as of September 15, 1948. Revisions of the Standard Specifications for Cement-Mortar Protective Coating for Steel Water Pipe of Sizes 30 in. and Over—7A.7–1941 have been scheduled for consideration by the committee.

4. *Reinforced Concrete Pipe.* The Tentative Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Not Prestressed—7B.1–T have been officially published. The committee, under Chairman E. W. Whitlock's direction, is now considering a preliminary draft of tentative specifications for reinforced concrete pipe—steel cylinder type, prestressed. After this task has been completed, the committee plans to consider the development of tentative specifications for reinforced concrete pipe—noncylinder type.

5. *Laying Cast-Iron Pipe.* The subcommittee, under Chairman J. P. Schwada's direction, has in hand the development of the mechanical standards for laying cast-iron pipe and is approaching the completion of its task. The committee document will be available for consideration by the Committee on Water Works Practice and the Board of Directors during the year 1949.

The subcommittee on disinfection procedure (now operating under the

chairmanship of B. A. Poole) is giving consideration to the deletion of jute or hemp as an acceptable material to be used in jointing bell-and-spigot cast-iron pipe. If jute is no longer listed as an acceptable material, the discussion concerning the methods for disinfection of jute may then be dismissed. A variety of other materials available in the field, several of which are being very widely used, means that the elimination of jute from the acceptable list will pose no problem for the water works construction field.

6. *Valves.* The Committee on Valves has essentially completed its program of consideration of various items for inclusion in the revised text of the current specifications. The material is to be transmitted to the A.W.W.A. office for staff editing.

7. *Sluice Gates.* Chairman T. J. Skinker of the Committee on Sluice Gates advises that, in his judgment, no broad revision of the present specifications is to be recommended by the committee. This document has been held in tentative form since 1941. It appears necessary to submit specifically to the committee, as well as to the Committee on Water Works Practice, copies of the present document and to request precise advice on whether or not the document should be advanced to Standard.

8. *Fire Hydrants.* The Committee on Fire Hydrants, under the chairmanship of Roger W. Esty, on December 30, 1948, submitted a report recommending three changes in the present document. However, since the present text of the hydrant specifications merits substantial editorial revision, it is planned to have this work done by the A.W.W.A. staff at the same time that the specifications for valves are being edited. It is planned to submit the completely re-edited document, with the specific changes recommended by Chairman Esty's committee, to the Committee on Water Works Practice and to the Association's member manufacturers of fire hydrants for review before the document is officially submitted to the Committee on Water Works Practice for approval.

It is also proposed to appoint a special subcommittee to prepare specifications for "wet-barrel" or "California type" hydrants, since a document of this character is needed.

9. *The Committees on Distribution System Safety and on Cross Connections* have been relatively inactive. Consideration is being given to the termination of the activities of these committees as presently constituted, as well as to the possible organization of a new committee with the suggested title of "Water Distribution Safety." This committee would cover the field previously assigned to the two separate groups.

10. *Meters.* The Tentative Standard Specifications for Cold Water Meters—Fire Service Type—7M.4–T are recommended by the committee to be advanced to Standard. The committee has under consideration specifications for cold water meters—current type, propeller driven. No changes in the other documents issued by the committee are recommended.

11. *Electrolysis and Electrical Interference.* This committee was reorganized during 1948. It has not as yet been assigned a specific series of tasks.

12. *Service Line Materials.* The committee has completed its Collected Standard Specifications for Service Line Materials—7S–CR (published in the August 1948 issue of the JOURNAL). The committee now has in progress

the "Recommended Procedure for Service Line Installations." This is an important operation and merits full support from all quarters within the Association.

13. *Recommended Standards for Threads for Underground Service Line Fittings.* The specifications (7T.1–1948) prepared by this committee, under the chairmanship of W. W. Brush, have been advanced to Standard status. It appears proper to discharge the committee, *but* to list Chairman Brush as *Advisor* on the subject matter of the committee's work, subject to later necessities for reorganization of the committee and committee action.

Water Purification Division Committee

14. *Manual of Water Quality and Treatment.* This document is now in the hands of the staff for publication. Reference is made to this enterprise in the Report of the Editor (p. 279, *this issue*).

15. *Specifications and Tests for Water Purification Chemicals.* These documents are being given final editorial revision by J. E. Kerslake, Secretary, Water Purification Division, and will be sent to the A.W.W.A. office. They will be published as rapidly as editorial staff conditions permit.

16. *Water Distribution System Problems.* This committee is active and will present a progress report at the Annual Conference.

17. *Specifications for Zeolites.* The tentative manual has been revised by the committee and is now titled "Manual of Cation Exchange Test Procedures." It has been approved by the Committee on Water Works Practice and by the Board. It will be issued as a reprint as promptly as the printer can produce it.

18. *Loading Capacities of Water Treatment Plants.* The panel discussion relating to the subject matter of this committee's activities was conducted during the 1948 Conference. The committee proposes to file further reports relating to its activities during the 1949 Conference. Certain questions of policy have arisen during the activities of the committee which will be discussed later in this report.

19. *Water Conditioning Methods to Inhibit Corrosion.* This committee has been reorganized with Kenneth W. Brown as chairman. No report of the committee's work has been submitted.

20. *Specifications for Filtering Materials.* The revision of this document has been circulated for approval. The approval is complete and the document is scheduled for publication in the JOURNAL at the earliest available moment.

21. *Open Air Reservoirs.* A progress report of this committee was made in 1948, and a further report is scheduled for the 1949 Conference.

22. *Disposal of Wastes From Water Purification Plants.* A progress report of this committee was made in 1948 and a further report is scheduled for the 1949 Conference.

23. *Standard Methods for the Analysis of Water and Sewage.* This is a new committee which has been set up by the Water Purification Division in accord with the terms of the agreement between the A.W.W.A., the A.P.H.A. and the F.S.W.A. The committee will serve as the referee group on all matters related to water examination methods which are referred to it by the Joint Editorial Board. This board, as now set up to prepare the tenth edition, consists of H. A. Faber, representing the A.W.W.A., and chairman of the committee; Mac Harvey McCrady,

representing the A.P.H.A.; and W. D. Hatfield, representing the F.S.W.A. This long-term operation continues to be a perfectly satisfactory enterprise and a good example of well coordinated effort between associations.

Joint Committees With Other Organizations

24. *Joint Research Committee on Boiler Feedwater Studies.* This committee held its annual meeting on December 2, 1948. During the year 1948 three committees were set up to study the problems of [1] deposition, [2] corrosion and [3] steam contamination.

25. *Water Works Terms.* An agreement has been reached between representatives of the A.W.W.A., A.P.H.A., A.S.C.E. and F.S.W.A. which establishes a basis for funding the cost of typesetting the *Glossary—Water and Sewage Control Engineering.* The document will be published for sale at a tentatively scheduled price of $1.00 per copy for paper-bound copies and $2.00 per copy for cloth-bound copies. Each one of the four sponsor associations is scheduled to underwrite its share of the printing costs and use the facilities of its own publications to promote the sale of the number of copies which it has underwritten.

26. *Field Welding of Steel Water Pipe Joints.* This is a joint committee of the A.W.W.A. and the A.W.S. While some suggestions for revision of the text of the specifications (7A.8–T) have been made, the committee personnel have not approved the recommendations.

27. *Steel Standpipes and Elevated Tanks.* A substantial revision of this document (7H.1–1943) was approved as of September 20, 1948. Reprints of the revised text have been published. The committee has under consideration a minor amendment relating to the design of the roof entry hatch.

28. *Recommended Practice for Inspecting, Repairing and Repainting Elevated Tanks.* This document (7H.2–T) has been approved by the A.W.W.A., the N.E.W.W.A. and the A.W.S. While certain minor suggestions have been made looking toward amendment of the text, no significant requirement of the document has been criticized.

29. *Flanges for Steel Water Pipe.* This joint activity of the A.S.M.E. and the A.W.W.A. has under consideration the records of certain experimental studies made by R. E. Barnard. No definite information is at hand concerning the completion of the work of the committee.

30. *Correlating Committee on Cathodic Protection.* Aside from the release of a general document relating to the nature of, and need for, cathodic protection of underground pipelines ("Cathodic Protection of Buried Metallic Structures Against Corrosion," in May 1948 JOURNAL, Vol. 40, p. 485), the various subcommittees of this joint committee have not recorded their progress.

31. *Cast-Iron Pipe and Special Castings.* This committee, operating under American Standards Assn. procedure, has had several conferences during the year. It is reported that the following documents have been cleared by the committee and will be presented shortly to the A.W.W.A. staff for preliminary publication: *new documents*—Pipe Centrifugally Cast in Metal Molds for Water (A21.6); Pipe Centrifugally Cast in Sand-lined Molds for Water (A21.8); and Short Body Fittings for Water and Gas up to and Including 12-in. Diameter (A21.10); *revised docu-*

ments—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe (A21.1–1939); and American Standard Specifications for Cast-Iron Pit-cast Pipe for Water or Other Liquids (A21.2–1939).

The A.W.W.A. will undertake the task of obtaining the approval of these documents by the other sponsors of the committee; namely, the American Gas Assn., the American Society for Testing Materials and the New England Water Works Assn.

32. *Manhole Frames and Covers.* The American Standards document, which was published by the A.W.W.A. in 1942, has by no means received the amount of attention which it deserves. The standards are valuable. The committee is inactive.

33. *Standardization of Plumbing Equipment.* This committee, which was organized in 1927, had as its primary purpose the development of a plumbing code. During the course of its existence it has developed several standard documents, and it is just now about to receive approval for the work of its subcommittee on plumbing codes. There has recently been held a meeting of persons representing several agencies who desire, when the A.S.A. code is adopted, to coordinate this document with codes developed by [1] the Government Housing Agencies Uniform Plumbing Code Committee, [2] the Building Officials Conference of America, [3] the Western Plumbing Officials Conference and [4] the American Society of Sanitary Engineering. It should, of course, be evident to anyone that the promulgation of five separate codes in the field of plumbing is highly undesirable, confuses the engineering field and increases the cost to the consumer. The A.W.W.A., through its Secretary, has clearly indicated to the conference group that this Association considers any effort toward coordination of the various codes and the development of a single uniform code for plumbing in the United States a highly desirable enterprise to which the A.W.W.A. will give complete support.

34. *Pipe Threads.* This committee is active, having released a number of significant documents within recent years.

35. *Pipe Flanges and Fittings.* During the year the following documents have been approved by this committee: Revision to American Standard Cast-Iron Screwed Fittings, 125 psi. and 25 psi.; Revision to American Standard for Ferrous Plugs, Bushings, Lockouts and Caps (B16.14–1943); and Proposed American Standard Brass or Bronze Screwed Fittings, 250 psi.

36. *Code for Pressure Piping.* The committee for this project has been completely reorganized during 1948 and a complete revision of the existing code is scheduled.

37. *National Electrical Code.* The development of a revised text of this important document is now in progress. F. E. Dolson has been appointed to represent the A.W.W.A. on the Electrical Grounding Subcommittee.

38. *Letter Symbols and Abbreviations.* W. E. Howland of Purdue University has been appointed to this committee to succeed W. E. Malcolm, deceased. The committee has, during 1948, made progress on "Letter Symbols and Abbreviations for Science and Engineering."

39. *Specifications for Sieves.* This committee is inactive.

40. *Standardization of Graphical Symbols for Use on Drawings.* This committee is very active. The Association is competently represented by W. V. Weir. Revisions of "Graphical

Symbols for Use on Drawings in Mechanical Engineering" are under consideration by this committee.

41. *Dimensions of Wrought Iron and Steel Pipe.* The committee has under consideration a proposed new American Standard for stainless steel pipe and the revision of the basic standard (A.S.A. B36.10) for wrought-iron and wrought-steel pipe.

42. For several years there has been operating within the California Section a Committee on Coefficients of Flow in Steel Pipelines. Julian Hinds is chairman, and the other members of his committee are W. W. Hurlbut, L. W. Grayson, J. S. Longwell, F. D. Pyle and F. C. Scobey. It appears proper to consider the transfer of this committee to a national level by making it a subcommittee of the Steel Pipe Committee and adding to it capable representatives of the Association from other parts of the United States and Canada.

43. The Southern California members of the A.W.W.A., in conjunction with the Southern California members of the A.S.M.E., have manifested an active interest in the development of standards for rotary cône valves and for deep well vertical pumps. This interest has been brought to the attention of staff executives of the A.W.W.A. and the A.S.M.E. The situation was discussed on January 11, 1949, and a communication was sent by S. A. Tucker, Standards Manager of the A.S.M.E., to the A.S.A. recommending that the establishment of sectional committees to cover these two subjects be considered.

The establishment of A.S.A. sectional committees will require that the geographic representation be substantially widened beyond the Southern California area. Consideration has been given to this aspect of the situation. In the early discussions it was intimated that the standards might be made joint projects of the A.S.M.E. and the A.W.W.A. If the operations are carried on under A.S.A. procedure, it will probably be desirable for the A.S.M.E. to accept sponsorship of the project for rotary cone valves and for the A.W.W.A. to handle the deep well vertical pumps project. Under A.S.A. procedure, each association would be represented in the project sponsored by the other, and other groups having an interest in the subject matter would naturally be called into consultation and participate in the committee work.

As both subjects are of considerable importance to the water works industry and subject to Board approval, the Committee on Water Works Practice proposes to establish the proper A.W.W.A. relationships to both projects.

44. *Asbestos-Cement Pipe.* It is proposed to reactivate the Committee on Specifications for Asbestos-Cement Pipe. A prior committee organized to develop emergency specifications during the recent war was unable to reach an accord and was discharged. It is considered important that an A.W.W.A. standard for this material be promptly developed.

45. The Copper and Brass Research Assn. has set up with its own personnel a committee on the corrosive effect of water on copper tubing. The A.W.W.A. has been represented in the preliminary meeting of the committee and is prepared to cooperate with the Copper and Brass Research Assn. to the fullest extent required by it.

46. Incidental to the activities of the Water Purification Division's Committee on Practical Loading Capacities of Water Treatment Plants, certain questions have arisen concerning the propriety of members of the committee making—at section meetings of the

A.W.W.A. or elsewhere—public presentations of opinions which the individuals hold concerning activities of the committee when the committee is not fully in accord with the speaker's viewpoint. It appears proper to recommend, as a general principle of A.W.W.A. Engineering Practice Committee action, that the fullest possible publicity be given in section or general meetings of the Association to activities which committees are carrying on. The exchange of ideas between committee members and members of the Association who are not related to the committee activity is bound to be productive and valuable. On the other hand, it appears desirable to set up, on general principles, an arrangement which would obligate any committee member to advise the other members of the committee of his intention to speak before a section meeting if he has committed himself to do so. This will give the other members of the committee an opportunity to join in the discussion, whether they wish to concur in, or differ with, the opinions expressed by the original speaker. The expected result is that, with the fullest discussion of committee problems, even though there is a temporary difference of opinion among members of the committee upon specific problems, there is bound to be produced beneficial and productive information which will be in the interest of the water supply industry.

47. The Committee on Water Works Practice proposes to give consideration to the water supply standards recently developed by a special committee of the California Section (published in the January 1949 JOURNAL) to see whether or not the document, as it now stands, or with modifications indicated by a wider field of applicability, can be accepted as an Association standard or recommendation.

Board Action

Acting on the recommendations of the chairman of the Committee on Water Works Practice, the Board:

1. Approved the dissolution of the present Committee on Deep Well Pumps.
2. Approved the establishment of a committee to prepare standards for "wet-barrel" hydrants.
3. Approved the dissolution of the Committees on Distribution System Safety and on Cross Connections.
4. Approved the establishment of a Committee on Water Distribution Safety.
5. Advanced the specifications for cold water meters—fire service type to Standard.
6. Approved the A.W.W.A. Water Purification Division committee on *Standard Methods*.
7. Reaffirmed the desire of the A.W.W.A. that Committee A21 develop standards for mechanical joints for cast-iron pipe.
8. Approved participation by the A.W.W.A. in the standardization of rotary cone valves and deep well pumps under A.S.A. procedure; proposed A.W.W.A. sponsorship for specifications for deep well pumps.
9. Authorized the Steel Pipe Committee to expand to national scope the California Section Committee on Coefficients of Flow in Steel Pipelines.
10. Approved the activation of a Committee on Asbestos-Cement Pipe.
11. Approved the issuance of a statement of policy relating to discussions of subjects under consideration by Water Works Practice committees.
12. Approved, in principle, the development of "Standards of Minimum Requirements for Safe Practice in the Production and Delivery of Water for Domestic Use."

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1948

A report of the activities of the Committee on Water Works Administration for the year ending December 31, 1948, submitted to the A.W.W.A. Board of Directors Jan. 17, 1949, by W. R. LaDue, Chairman.

FOLLOWING discussions previous to and at the 1947 San Francisco Conference, the Committee on Water Works Administration was created by amendment to Article IX (Standing Committees) of the Association's By-Laws, effective October 23, 1947. W. R. LaDue was appointed by President Veatch to outline the work of the committee and to organize its personnel. A preliminary report indicating procedure was submitted to the Board of Directors at the January 1948 meeting in New York. Following further amplification of objectives, the subject was presented to the Board at the 1948 Conference, at which time the organization plan was accepted and the suggested committee personnel was appointed by the Board of Directors in accordance with Section 3.1 of Article IX of the By-Laws.

A joint meeting of this committee with the Water Works Practice Committee was held at the 1948 Conference. This was followed by a second meeting of the Committee on Water Works Administration during the Conference. These meetings were of great value in setting up and delimiting the work of the committee.

The present organization provides for seventeen subcommittees grouped in four classifications, as outlined on pages 263–267 of the 1948 Membership Directory. The Committee on Water Works Administration consists of the committee chairman, the general chairmen of the four groups and the chairmen of the various active subcommittees. Other members of the various subcommittees are not members of the Committee on Water Works Administration. The present status of committee personnel and activity is as follows:

Committee on Water Works Administration

W. R. LaDue, *Chairman*

F. C. Amsbary	A. P. Kuranz
C. J. Alfke	D. L. Maffitt
M. B. Cunningham	L. A. Smith
E. F. Dugger	L. N. Thompson
L. S. Finch	L. S. Vance
M. P. Hatcher	W. V. Weir

Committee A1—Organization and Administrative Policy

W. V. Weir, *General Chairman*

Committee A1.A—Municipal Water Works Organization: *active.*

Committee A1.B—Radio and Mobile Communication Facilities for Water Works: *active.*

Committee A1.C—Water Use in Air Conditioning: *active.*

Committee A1.D—Water Use in Fire Prevention and Protection: *active.*

Committee A1.E—Construction, Equipment and Material Contracts: *inactive.*

Committee A2—Public and Worker Relationships

D. L. Maffitt, *General Chairman*

Committee A2.A—Public Relations: *active.*

Committee A2.B—Management Relations: *inactive.*

Committee A2.C—Compensation of Water Works Personnel: *active.*

Committee A2.D—Pension and Retirement Plans: *active.*

Committee A3—Financing

E. F. Dugger, *General Chairman*

Committee A3.A—Taxation and Fund Diversion: *inactive.*

Committee A3.B—Valuation and Depreciation: *inactive.*

Committee A3.C—Cost Trends: *inactive.*

Committee A3.D—Water Main Extension Policy: *active.*

Committee A4—Accounting and Statistics

A. P. Kuranz, *General Chairman*

Committee A4.A—Water Department Reports: *active.*

Committee A4.B—Water Rate Schedules: *inactive.*

Committee A4.C—Joint Administration of Water and Sewer Facilities: *active.*

Committee A4.D—Water Consumption: *inactive.*

It is highly possible that the committee activities at the 1949 Chicago Conference will include reports, papers or panel discussions on the work of the following subcommittees: A1.B—Radio and Mobile Communication Facilities for Water Works, A1.C—Water Use in Air Conditioning, A2.C—Compensation of Water Works Personnel, A2.D—Pension and Retirement Plans, A3.A—Taxation and Fund Diversion, A3.D—Water Main Extension Policy, A4.A—Water Department Reports and A4.B—Water Rate Schedules.

During the meeting of the committee at the Chicago Conference, the activation of the following committees will be carefully considered:

A2.B—Management Relations. It is believed that this phase of the worker relationship is a natural outgrowth of and corollary to our continuing program on public and personnel relations.

A3.A—Taxation and Fund Diversion. In the search for additional general state, county and city revenues, the enviable "untouchable" position of water works in many states is now receiving its share of careful and not too friendly scrutiny. Our present position in this field ranges all the way from no taxation and no diversion to full taxation and unlimited, but relatively controlled, diversion.

A4.B—Water Rate Schedules. The activation of this committee seems advisable if we are to keep our members informed of the apparent policies of some agencies in seeking water contracts at preferred minimum rates.

It has been the aim of the committee to proceed slowly, and, upon obvious member demand, to establish a long-time policy of continuing activities, and to maintain close cooperation with the older Committee on Water Works Practice. The Board's ever valued counsel, consideration and advice are appreciated.

Report of the Editor

For the Year Ending December 31, 1948

A report on the publishing activities of the Association submitted to the A.W.W.A. Board of Directors on January 18, 1949, by Eric F. Johnson, Editor.

IN 1948 the JOURNAL weathered another year of rising costs, although, in providing increased service, it suffered some reduction of the margin between advertising income and total expense. The long awaited *Quest for Pure Water* was successfully launched, and work on two other Association publication projects progressed to the point of making their completion in 1949 possible. Finally, as a result of expanded promotional activity, sales of reprints and other publications were increased to new high levels.

A detailed report of the Association's publication projects follows:

1. The Journal

a. *Contents.* During the year the size of the JOURNAL was expanded to regain losses sustained in 1947. Thus, in 1948 total pages were 2,464, compared with 2,324 in 1947 and 2,466 in 1946.

Included in the above total were 1,218 text pages, 66 more than in 1947, containing 123 technical articles, of which 67 were Annual Conference papers; 43, Section Meeting papers; and 13, contributions from the field. In addition, 16 official Association documents or reports were published.

Water works literature was again given extended coverage, the number of pages of abstracts in 1948 being 148, compared with a 1947 total of 146 and a 1946 total of 123.

Finally, 1,088 pages were devoted to news, editorial matter, Association announcements and advertising, compared with 1,026 pages in 1947 and 1,012 pages in 1946. The increase in this portion of the JOURNAL is again directly attributable to an increased number of full-page advertisements.

A new series of increases in printing costs beginning in November 1948 has forced the JOURNAL staff to plan extensive economies for 1949. By close control over the length of articles, by relocation of the abstracts section and by some curtailment of both abstracts and news items, it expects to cut the overall size of the 1949 JOURNAL to 2,304 pages. In the realization of these economies, however, no reduction in the overall amount of space devoted to technical articles or other text material is contemplated.

b. *Cost.* The total 1948 cost of printing and production was \$39,530.19, compared with a 1947 total of \$33,884.22. Because more copies of each issue were printed—an average of 8,314 compared with 7,810 in 1947—and because of economies in production, unit costs did not rise in proportion. They did rise, however, from \$1.824 per 1,000 pages printed in 1947 to \$1.891 per 1,000 pages printed in 1948;

and, primarily because the issues averaged 14 more pages in length, average costs per issue jumped from 36.2¢ in 1947 to 39.6¢ in 1948.

Although the growth of JOURNAL print orders at a rate of approximately 500 copies per year has had a marked effect on total costs, inflated prices alone bear the blame for increased unit costs. Again in 1948 new rates were applied by the printer, so that, based on a 1943 index of 100, *printing costs now stand at 174,* compared with 145 only a year ago. And paper costs rose even more drastically, to the extent that, despite the substantial economies effected by purchase in carload lots, 1948 supplies were billed at a price index of 185, compared with 176 in 1947, when paper was purchased in small lots at penalty prices.

Making allowance for these increases and for such further advances as appear inevitable, cost estimates for 1949 have been developed on a basis of absorbing half the increased costs and avoiding the other half by the above-mentioned reduction in size and by further economies in drafting, engraving and other production work.

c. *Income.* For the year 1948 all JOURNAL income totals slightly exceeded anticipated earnings.

Income represented by the proportion of dues payments applicable to JOURNAL subscriptions again rose to keep pace with the proportion of JOURNAL costs attributable to increased print orders. And nonmember subscription income exceeded by more than 10 per cent the optimistic estimate made in January 1948.

The most gratifying increase, however, was the approximately 7 per cent rise in advertising income which was realized in the face of a general sharp decline in magazine advertising. More than merely a money gain, this new high in advertising income represented a new high, too, in space sold: a total of 729 pages, compared with 692 in 1947 and the previous high of 709 in 1946 which was earned at a lower space rate. Based on current commitments, it is now predicted that both space sold and advertising income will rise again in 1949.

With circulation already up 18.5 per cent since the last rate increase was announced in the summer of 1946, with printing and paper costs up 52 and 27 points respectively since that time, and with the margin between income and expense diminishing constantly, it now appears necessary and proper to plan another advertising rate increase. It is the conviction of the JOURNAL staff that no further economies than those planned for 1949 can be effected without seriously reducing the value of the JOURNAL both to the membership and to the advertisers who support it. Thus, on the basis that the JOURNAL should be maintained at its present high standard of service and value to both the field and the Association, and on the basis that its constant and rapid growth in circulation has again increased its monetary value to advertisers, it is recommended that the Board authorize a 20 per cent increase in JOURNAL advertising rates to become effective in 1950. In further justification of such an action, it may well be pointed out that, even after an increase of that order, JOURNAL space rates will be lower than those of other publications in the field despite the fact that its net paid circulation is the largest.

2. Membership Directory

The 1948 edition of the biennial Membership Directory, issued as a supplement to the December JOURNAL, was by far the largest in Association history. Relief from paper shortages made it possible to resume inclusion of advertising and of a number of service features for the first time since 1942; it was not this enlargement, however, but conditions in the printer's plant, which almost made the issue a triennial.

In its 384 pages, the 1948 directory contained 48 more pages of membership and committee lists than did the 256-page 1946 edition, and the additional 80 pages included 44 pages of advertising plus 36 pages of information concerning Associate Member products and services, an engineering services directory and a recommended list of books on water supply.

Total cost of the directory exceeded by 9 per cent the amount originally budgeted in January 1947, primarily because printing and paper costs increased in the interim, but through the use of a less expensive paper for the main portion of the book, through production economies and through an increased print order, it was possible to hold the unit cost to $1.764 per 1,000 pages printed, compared with $1.775 per 1,000 pages printed in 1946. And although the cost per copy of the greatly enlarged 1948 edition was 68.5¢, compared with 46.1¢ for the 1946 directory, this difference was more than offset by the 32.6¢ per copy realized from the sale of advertising.

Since further enlargement of the directory would make the book both too costly and unwieldy, substantial economies in space—possibly by reduction of type size, certainly by such curtailment as is consistent with maintaining the usefulness of the volume—are contemplated for the next edition. In respect to net costs, it should be pointed out that a great deal more advertising revenue can be expected from the 1950 edition, both because its value will be more generally realized from the example of the 1948 issue and because it will be possible then to announce the availability of space to prospective advertisers before their 1950 advertising appropriations have been established.

3. Journal Indexes

The sale of 11 copies of the 1881–1939 Index during 1948, compared with 13 copies in 1947, left a balance of 256 copies in stock. Of the 1940–1944 Supplement, approximately 250 copies remain in stock after 1948 sales. Preliminary work on the 1950 Supplement has been carried forward with the idea of changing its form to a more useful consolidation of annual indexes, and thought has been given to making it available for purchase only, rather than through an original free distribution.

4. Standard Methods

Approximately 2,600 copies of the second printing of the ninth edition of *Standard Methods for the Examination of Water and Sewage* were sold during 1948, leaving a balance of approximately 2,400 copies in stock of the total of 12,000 printed in 1947. Meanwhile, a new Joint Editorial Board, under the chairmanship of Harry A. Faber, has begun work and planning on the tenth edition tentatively scheduled to appear in 1950.

5. Accounting Manual

During 1948, 51 copies of the *Manual of Water Works Accounting* were sold,

compared with 54 copies in 1947 and 21 in 1946. As a direct result of a mid-December promotion of Association books, however, approximately 45 additional copies of this volume were sold during the first week of January 1949.

6. Specifications

During the year three official Association documents were approved and published in the JOURNAL. These were: [1] the procedure for disinfecting mains; [2] the tentative recommended practice for tank maintenance; and [3] the tentative specifications for reinforced concrete pipe. All are now available in reprint form.

Although sales of a few specifications documents were retarded pending revision, overall sales during 1948 increased to the extent that income therefrom exceeded the budget estimate by more than 44 per cent.

7. Manual of Water Quality and Treatment

On January 1, 1949, Editorial Coordinator George E. Symons completed his work on the last two chapters of the *Manual of Water Quality and Treatment*, so that, except for a few loose ends, the entire manuscript is now in the Association's hands. Final details of styling and design and a production schedule now await a conference with the printer to be held during the latter part of January. Then, depending upon the printer's capacity to handle the job, work can begin immediately on setting type. With a maximum of cooperation by the printer and with a virtually single-minded approach to the job in the Association office, the book could be issued before the end of 1949, but it may be more realistic not to expect it before the spring of 1950. At any rate, a major effort will be made to bring the manual out at the earliest possible date.

8. Survival and Retirement Book

During 1948, its second year in print, 69 copies of *Survival and Retirement Experience With Water Works Facilities* were sold, leaving a balance of 571 bound and 1,000 unbound copies in stock. As with the accounting manual, the mid-December promotion resulted in a sale of approximately 45 copies of this book during the first week of January 1949.

9. The Quest for Pure Water

On September 28, 1948, almost two months later than expected, 1,012 copies of *The Quest for Pure Water* were completed and approximately 280 copies shipped immediately to the members who had subscribed for the book in advance of publication. A steady stream of sales has followed its issue, so that, by the end of the year, a total of 506 copies, exactly half of the printing, had been distributed. And during the first week in January 1949 more than 55 additional copies were sold, again primarily through the single promotional mailing in mid-December.

Because the book has received widespread publicity, because it is a valuable reference work—the worth of which will be increasingly appreciated as it is used—and because it will not become obsolete with age, it is felt that the present stock of 400-plus copies will not be sufficient to meet the total demand. It is therefore recommended that the Board authorize immediate action on a second and final printing of 1,500 copies, 500 to be bound immedi-

ately and the rest to be held in flat sheets for later binding. This action would make it possible to release the type now being held at an expense of approximately $10.00 per month, and sales of a second printing will enable the Association to recover some of the substantial losses involved in selling the first printing at approximately $3.00 per copy less than it cost. It is estimated that such a project would require a maximum appropriation of $2,000.

10. Depreciation Study

Work has not yet begun on Henry Earle Riggs' *The Troublesome Problem of Depreciation*, publication of which was approved at the 1947 San Francisco meeting of the Board. The much greater demand for copies of the *Manual of Water Quality and Treatment* has dictated postponement of the Riggs book until the manual is under way. If the printer's production situation improves substantially during 1949, there will be no reason—other than lack of adequate staff time—to delay work on the depreciation book until the manual is completed.

11. Water and Sewage Glossary

Begun in 1936, work on the *Glossary—Water and Sewage Control Engineering,* in which the Association has been joined by the American Society of Civil Engineers, the Federation of Sewage Works Assns. and the American Public Health Assn., is finally ready for printing. Arrangements are now being made to share the expense and income of the first printing of between 2,500 and 5,000 copies which will be ready sometime in March 1949. And the Association has committed itself to sell 500 copies of this book to its members at a special price of $1.00 per copy for a paper-bound edition and $2.00 per copy for a cloth-bound edition.

Board Action

Acting on the recommendations of the Editor, the Board of Directors:

1. Authorized a 20 per cent increase in JOURNAL advertising rates, to become effective January 1, 1950.
2. Authorized reprinting of *The Quest for Pure Water,* subject to Executive Committee approval, and approved a $2,000 appropriation for that purpose in the 1949 budget.

The George Warren Fuller Award

A statement, approved by the Board of Directors on January 17, 1949, of the terms and conditions under which the George Warren Fuller Award shall be bestowed.

IN memory of George Warren Fuller and his life of distinguished service to the water works profession and, particularly, to the American Water Works Association, the Board of Directors of this Association established, in 1937, the George Warren Fuller Award. This award consists of an engraved certificate bearing a likeness of George Warren Fuller, signed by the President and Secretary of the Association.

The recipients of the George Warren Fuller Award are selected by the individual Sections of the Association from among their own members in accordance with the "Terms and Conditions" set forth below. *Such selection is presumed to recognize publicly the contribution toward the advancement of water works practice which the individual has made within the particular section which designates him for the award.*

Terms and Conditions

The terms and conditions under which the George Warren Fuller Award shall be awarded follow:

1. Each Section of the Association *may,* each year, select one of its members to receive the Fuller Award. The award may be conferred upon any individual member (Active, Junior, Honorary) or duly appointed representative of a Corporate Member or a Municipal Service Subscriber of the American Water Works Association in recognition of his leadership qualities and/or for his contribution toward the advancement of water works practice within the particular Section nominating him for the award. When two or more individual members of a Section have cooperated in the project for which an award is granted, a joint award may be conferred.

2. Emphasis is placed upon the fact that conferring the Fuller Award is in no sense mandatory. The decision to confer an award in any year shall be made only if it is felt, after careful deliberation, that one of the Section members actually *qualifies* for the award. Greater profit to the Section and to the Association itself will accrue from a report recommending "no selection" than from one which casually adds another name to the distinguished list of Fuller Awardees.

3. Decision concerning the conferring of an award shall be placed in the hands of a Fuller Award Committee, which shall, whenever practicable, be appointed and announced at least six months prior to the Section's annual meeting.

4. The Fuller Award Committee of each Section shall be appointed by the Section Chairman. It shall consist of five members, all of whom shall be former recipients of the Fuller Award if possible. If five Fuller Awardees are not available to serve on the committee, it is recommended that the other members be chosen from among the Section's water works superintendents, from the staff of the engineering divi-

sion of the state department of health and/or from the leaders of the water works schools within the Section.

5. The Fuller Award Committee of each Section shall be set up on a rotating basis, with one new member being appointed each year to serve a five-year term and with the senior member designated chairman of the committee. Under this system, each member will become chairman in the fifth and final year of his service on the committee and will retire from the committee when his report for that year is accepted by the Section. New Sections will of course have to establish the rotation system by appointing their first committees for staggered terms of from one to five years, designating as chairman the member appointed for one year. In such instances the earliest recipient of the Fuller Award should be appointed the first chairman of the committee.

6. Each member appointed to a Section Fuller Award Committee shall be furnished with a copy of these "Terms and Conditions" as well as with a copy of the statement on the life and works of George Warren Fuller to guide him in the exercise of his duties on the committee.

7. When, after its deliberations in any one year, a Fuller Award Committee makes a selection, it shall submit the name and qualifications of the proposed recipient to the Executive Committee (or equivalent official group) of the Section for approval not less than 30 days prior to the annual meeting of the Section.

8. The report of the committee shall include a "citation" or statement of the basis upon which the recommendation is made. Such citations shall follow the pattern of form and general phraseology indicated by the lists which have been prepared each year and which are uniformly published in the December issue of the JOURNAL as a part of the record of the year's convention. Citations should, in general, contain not less than 30 nor more than 40 words, to the end that a recipient be neither under- nor over-praised for the work that he has done. The Secretary will make such editorial adjustments in citations as may be deemed necessary in the general interest.

9. The announcement of the award shall be made a part of the annual meeting of the Section granting it, and shall be made by the Association's official representative at the Section meeting, or by the presiding official of the Section. The reading of the committee report should be accompanied by the reading of as much of the prepared statement concerning the life and works of George Warren Fuller as fits the occasion.

10. The formal ceremony of presentation of certificates of award is made a part of the annual meeting of the Association. If, in special cases, the awardee is unable to attend the following general convention, the presentation of the award certificate may be made at the Section meeting. If it is desired to present an award certificate at a Section meeting, the report of the committee with the citation and full name of the awardee shall be transmitted to the headquarters office of the A.W.W.A. 30 days in advance of the Section meeting, along with an appropriate statement of the reason for the prospective absence of the awardee from the general convention of the Association.

11. The names of the recipients of the memorial awards for the convention year are announced in an appropriate manner during the annual meeting of the Association at the time the cere-

mony of awards takes place. In the published list of members of the Association, a designation is made indicating the members who have received the George Warren Fuller Awards.

12. Each Fuller Awardee automatically becomes a member of the George Warren Fuller Award Society of the American Water Works Association. No initiation fee or annual dues are required for membership in this society. The annual meeting of the society is held during the annual convention of the Association.

George Warren Fuller, 1868–1934

"Little can be said about George W. Fuller without recalling a thousand and one connections which he has had with sanitary engineering practice in this country and abroad. Amazingly active mentally, he always catalyzed those individuals who were fortunate enough to work with him. An enthusiasm, tempered by seasoned judgment and reinforced by a remarkable technical equipment, accounted for the fact that his name is identified with almost every important sanitary advance in this country in the last four decades. . . . Many, however, are born at the right time who are either ill equipped or are lacking in sufficient vision to make the most of that good fortune. In Mr. Fuller's case, heredity and environmental influence, coupled with remarkable energy, all contributed to the development of a practitioner of outstanding stature. He will be remembered long in the future, as much for his distinctive personal characteristics as for his long list of contributions to sanitary science and practice." Thus wrote Abel Wolman editorially in *Municipal Sanitation* after Fuller's death on June 15, 1934.

George Warren Fuller was born in Franklin, Mass., December 21, 1868, on the farm which was part of the land acquired by the family during the revolutionary period. Three or four Fullers came to Massachusetts from England before the middle of the seventeenth century. The one with whom we are concerned was Ensign Thomas Fuller, who, in 1642, by vote of the people of Dedham, was "admitted"—a prerequisite to citizenship at that time—to the purchase of Martin Phillips' lot. He seems to have been a capable and versatile man. He was surveyor for several years after 1660 and selectman for fourteen years; he repeatedly represented the community at the general court, was cotrustee of money bequeathed for the establishment of a Latin school and laid out the road to Cambridge as well as many minor ones. He kept the town's ammunition, for which he was paid ten shillings a year, but had considerable trouble in collecting the fee, part of which he remitted, at one time, in order to obtain settlement. In the succeeding line, down through Grandfather Asa Fuller, who was a minuteman, there continues to be activity of a civic nature—service as selectmen, court representatives and the like.

George Warren Fuller was at the head of his class when he attended the Dedham schools. His scholarship was, of course, a source of great satisfaction to his mother. At sixteen he passed the examination for entrance at M.I.T. but, his father having died a few weeks before, it was thought best for him to have a fourth year in high school, after which he was graduated at the head of his class and with the highest marks given up to that time. At M.I.T. he met and came under the

influence of such people as William T. Sedgwick, Ellen H. Richards and Hiram F. Mills, all enthusiastically interested in the new science of public health. Their influence was felt throughout his life. Following his graduation, he spent a year at the University of Berlin and in the office of Piefke, engineer of the Berlin water works. On his return to Massachusetts, he was employed by the state board of health for some five years, during the latter part of the period being in charge of the Lawrence Experiment Station where he extended the experimental work and studies started by another famous chemist and engineer, Allen Hazen. The Lawrence Experiment Station was then recognized as leading in research on the purification of water supplies and treatment of sewage in this country. Fuller's brilliant achievements in this field attracted such attention to his ability that he was selected in 1895 to take charge of the experiments at Louisville, Ky., in the use of rapid filtration for its water supply. Immediately after he had accomplished this work, he was offered a similar engagement in Cincinnati, Ohio. These experiments served to remove the questions which had been raised about the sufficiency of rapid filtration as compared with slow sand filtration for these municipalities, and, at the same time, established the value of mechanical filtration where conditions were such as to warrant its use.

During his 34 years of active practice as a consulting engineer—following the opening of his New York office and, later, the opening of branch offices in Kansas City, Mo.; Toledo, Ohio; and Philadelphia—Fuller advised more than 150 cities, commissions and corporations on their water supply and sewerage problems, the outstanding engagements including, among others, Washington, D.C.; New Orleans, La.; St. Louis; Indianapolis, Ind.; Kansas City, Mo.; Memphis, Tenn.; Wilmington, Del.; New Haven, Conn.; Lexington, Ky.; Minneapolis and St. Paul, Minn.; Montreal, Que.; the Shanghai, China, Water Co.; the International Joint Commission (Canada and United States boundary waters); the New Jersey Water Policy Commission; the North Jersey Water Supply Commission; the Hackensack Valley Sewerage Commission; and the Metropolitan Sewerage Commission of Rhode Island. For many of these engagements, his service included full control over all engineering work involved in the preparation of plans and contracts, as well as the actual construction.

Notwithstanding a busy life in active practice, Fuller gave freely of his time and energy to the upbuilding of his chosen profession through participation in the activities of technical societies, through contributions to the engineering press and through educational activities. His record in this respect is outstanding. He was a member of the American Water Works Association (President); the American Public Health Association (President); the Engineering Foundation (Chairman); the American Society of Civil Engineers (Vice-President); the American Institute of Consulting Engineers; the American Society of Mechanical Engineers; the Institution of Civil Engineers of Great Britain; the American Chemical Society; the American Society of Bacteriologists; the Engineering Institute of Canada; the Vereines Deutscher Ingenieure; the Association Generale des Hygienistes et Techniciens Municipaux of France; and the Franklin Institute.

Perhaps the most significant of Fuller's characteristics were his belief in

organization and his devotion to standardization.

In 1920, at the Montreal Convention of the A.W.W.A., Fuller negotiated the organization of a committee to codify and standardize water works practice. The Association before that time had developed a few specifications documents, but its relation to the preparation of those documents was not that of leadership but rather of cooperative participation. The group under his leadership and chairmanship was first called the Standardization Council, later the Committee on Water Works Practice. He continued to be a dominant influence in the A.W.W.A. during the time its constitution and bylaws were being substantially revised. At the New York Convention of the A.W.W.A. early in June 1934 (only a week before his death), Fuller was in constant attendance, participating in the sessions and continuing even then his stimulation of the activities of the Association and its elected leaders.

Within the A.W.W.A., A.P.H.A., A.S.C.E. and F.S.W.A. alone, today more than 40,000 professional and technical men in North America are indebted to Fuller for the guidance of their organizational readjustments in the 1920–30 period which made possible the standing that these associations have today.

George Warren Fuller was first of all a capable engineer, equipped with a mind that never closed a channel to new ideas. He was an inventive technician—first in the laboratory field, later in engineering and design. He was a skilled negotiator, a public relations counsel who never called himself one, but who by such skill persuaded reluctant city officials that they were very wise and right to authorize sanitary improvements. He was a loyal citizen who found himself able and willing to render service to his country during World War I. He was uncannily able to give ear to the ideas and aspirations of younger men in the field and to inspire in them some measure of the spirit of leadership that he possessed. He believed in the organization and assembly of technical and professional men and devoted himself fully to the advancement of their associations and societies to the end that they serve better through planned action and cooperation.

Fitting indeed were the words of M. N. Baker, in his editorial tribute in the *Engineering News-Record:*

> History will be better able than we are to appraise the contributions of George W. Fuller to the art of water purification, but history will not be so well able to appraise Mr. Fuller's personal qualities of understanding, kindliness, sound judgment and tact as are we who have been fortunate enough to have frequent contact with him in our daily work. . . . Here also should be recorded an acknowledgment of the debt the profession owes to Mr. Fuller, especially his chosen branch of the profession, for his liberal contributions of time and energy to its professional societies. It can be said without fear of contradiction that it was chiefly through his efforts that the American Water Works Association has been raised from the level of a social group to its present high standing as a technical organization. Mr. Fuller's passing also serves to re-emphasize the youthfulness of sanitary engineering and the fundamental nature of the contributions made by a generation of notable men, now largely departed—work that centered around the Lawrence experiments and laid the foundation for present design methods and practices in water filtration. . . . Fuller's achievements and those of others of his generation are a legacy to be utilized by the present generation to carry the art forward to greater perfection.

Tentative Standard Specifications *for* FILTERING MATERIAL

The American Water Works Association has approved and promulgated these Tentative Specifications for Filtering Materials as prepared in the course of the activities of the Water Purification Division and under the jurisdiction of the Committee on Water Works Practice. The requirements are based upon long term experience and are intended to be applied in the construction of filtration plants operating under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the installation in the particular locality concerned.

American Water Works Association

Approved as Tentative by the Board of Directors of the A.W.W.A. on November 15, 1948

First Printing, March 1949

AMERICAN WATER WORKS ASSOCIATION
Incorporated
500 Fifth Avenue, New York 18, N.Y.

Tentative Standard

Specifications for Filtering Material

Section 1—Scope

The purpose of these specifications is to provide a general basis for choosing and specifying underdrain gravel and filtering material for mechanical or rapid sand filters, and for placing such materials in the filter.

Section 2—Underdrain Gravel

Sec. 2.1—Physical Characteristics

Gravel shall be obtained from an approved source and shall consist of hard, rounded stones with an average specific gravity of not less than 2.5. Not more than 1 per cent by weight of the material shall have a specific gravity of 2.25 or less. The gravel shall contain not more than 2 per cent by weight of thin, flat or elongated pieces (pieces in which the largest dimension exceeds three times the smallest dimension) determined by hand picking; and shall be free of shale, mica, clay, sand, loam and organic impurities of any kind. (If acid water is to be filtered, the gravel should be tested for solubility in hydrochloric acid. *See* Note 2.1 (p. 292) and Sec. A2.2 of the Appendix (p. 298).)

Sec. 2.2—Porosity

The porosity of the gravel in each layer shall be not less than 35 per cent nor more than 45 per cent.

Sec. 2.3—Gravel Size and Layer Thickness

The gravel shall be screened to proper sizes and placed in the filters in layers, as specified in Table 1, and the gravel within each layer shall be uniformly graded. Gravel over ¼ in. in diameter may be screened through wire screens with square openings or plates with round openings. Wire screens shall be used for sizes smaller than ¼ in. Not more than 8 per cent of the weight of any layer shall be finer or coarser than the limits specified for that layer.

TABLE 1

Gravel Size and Layer Thickness

Gravel Layer	Layer Thickness* *in.*	Size Limits* *in.*
Bottom	——	— to —
2nd	——	— to —
3rd	——	— to —
4th	——	— to —
5th	——	— to —

* To be filled in by engineer or purchaser. *See* Note 2.3 (p. 292).

Sec. 2.4—Placing Underdrain Gravel

The filter tank shall be thoroughly cleaned before any gravel is placed and shall be kept clean throughout the operation. Gravel made dirty in any way shall be removed and replaced with clean gravel. The bottom layer shall be placed carefully by hand to avoid movement of the underdrain system and to assure a free passage for water from the orifices. Each layer shall be completed before the next layer above is started. For materials less than ½ in. in diameter, the workmen shall not stand or walk directly upon the gravel but upon boards which will sustain the

weight of the workmen without displacing the gravel. Any gravel becoming mixed shall be removed and replaced in layers as herein specified.

The correct thickness of each layer shall be obtained as follows: Before the gravel is placed, the top of each layer shall be marked on the side of the filter. The top of each layer shall then be leveled against a water surface held at the appropriate mark. None of the particles shall be less than half submerged, and there shall be no places where additional gravel can be placed without the particles extending more than one-half of their volume above the water surface.

Sec. 2.5—Measurement and Payment

For furnishing and placing underdrain gravel, as specified, the contractor shall receive the unit price per cubic yard specified in the contract. (*See* Note 2.5 (p. 294).)

Section 3—Filter Sand

Sec. 3.1—Physical Characteristics

In these specifications, filter sand is classified as material less than 2.0 mm. in diameter. Filter sand shall be composed of hard, durable grains, free of clay, loam, dirt and organic matter. Not more than 1 per cent by weight shall be flat or micaceous particles. (If acid water is to be filtered, the sand should be tested for solubility in HCl. *See* Note 3.1 (p. 294).)

TABLE 2a

Filter Sand Sizes

Per Cent Size	Range *mm.*
1	— to —
10	— to —
60	— to —
99	— to —

Sec. 3.2—Sand Sizes

In specifying sand sizes, either Sec. 3.2.1 or Sec. 3.2.2, *but not both*, shall be used.

3.2.1. Filter sand shall be well graded and material showing abnormal grading may be rejected. The particle size distribution shall be determined by screening through standard sieves,* Tyler $\sqrt{2}$ series or equivalent U.S. series. The per cent sizes shall be determined from a plot of the percentages of the material passing each sieve against the rated opening of the sieve, or the equivalent diameter of the grains. When so plotted, per cent sizes shall fall within the ranges given in Table 2a. The ratio of 60 per cent size to 10 per cent size shall not exceed 1.70, and no particles shall exceed – mm. (*See* Note 3.2 (p. 294) for suggestions on sand size to be specified.)

TABLE 2b

Filter Sand Sizes

Material Passing Sieve *per cent*	Sieve Number		A.S.A. Sieve Opening *mm.*
	Tyler No.	U.S. No.	
— to —		12	1.68
— to —	14	16	1.19
— to —	20	20	0.84
— to —	28	30	0.59
— to —	35	40	0.42
— to —	48	50	0.30
— to —	65	70	0.21

3.2.2. Filter sand shall be well graded and material showing abnormal grading may be rejected. The particle size distribution shall be determined by screening through standard sieves,*

* For accurate size classification, sieves should be calibrated. *See* Sec. A2.4 of the Appendix (p. 298) for procedure.

Tyler $\sqrt{2}$ series or equivalent U.S. series. When so tested, the percentage of material passing the several sieves shall be in accordance with Table 2b. (*See* Note 3.2 (p. 294) for suggestions on sand size to be specified.)

Sec. 3.3—Placing Sand in Filters

Sand shall be transported and placed carefully to prevent contamination of any sort, and sand made dirty before or after placing shall be replaced with clean sand. Sand shall be placed in the filter, preferably through water, so as not to disturb the top layer of gravel, and shall be finished off smooth to the proper elevation.

Sec. 3.4—Measurement and Payment

The final depth of sand shall be – in. (to be filled in by engineer or purchaser). The depth of sand shall be measured after the sand has been backwashed three times, at a rate to give 30 per cent expansion of the sand, and then allowed to compact by closing the backwash valve slowly. Final closure of the valve from the opening that gives 10 per cent expansion shall extend over not less than 30 seconds. The top layer of any very fine material shall be scraped off before measurement.

For furnishing and placing filter sand as specified the contractor shall receive the unit price per cubic yard specified in the contract.

NOTES

Each note is numbered to correspond with the number of the section to which it refers. For example, Note 2.1 refers to Sec. 2.1—Physical Characteristics (of underdrain gravel).

Note 2.1

If adequate supplies of dense gravel are available, an average specific gravity of 2.6 should be specified in place of 2.5.

Where filters follow lime softening plants or filter relatively alkaline waters (pH of 8.0, or higher), or where operations over many years have demonstrated the satisfactory nature of a gravel, acid solubility of the gravel is of minor importance. If aggressive or low-pH waters are to be filtered, however, the acid solubility test is needed to exclude gravel with harmful amounts of limestone or shells. In such waters, the solubility of the gravel, determined as specified under Sec. A2.2 of the Appendix (p. 298), should not exceed the following limits: for gravel sizes $\frac{3}{8}$ in. or larger, 10 per cent solubility; for sizes smaller than $\frac{3}{8}$ in., 5 per cent solubility.

Note 2.3

Many combinations of gravel layer sizes and thicknesses have been satisfactory. Typical specifications are shown in Table 3.

To assure the stability of the filter and to prevent the loss of sand through the gravel, or mixture of sand and gravel, the gravel layers should meet the following requirements:

1. The gravel within each layer should be well graded.
2. The top layer should consist of gravel not finer than $\frac{1}{16}$ in. nor larger than $\frac{3}{16}$ in.
3. Except where porous underdrain plates are used, the minimum gravel size of the bottom layer should be $\frac{3}{4}$ in. or larger.
4. For proper grading of intermediate layers: [1] the minimum particle size of any layer should be as large as the maximum particle size in the layer next above; [2] within any layer, the maximum particle size preferably should be not more than two times the minimum particle size and in no event more than three times the minimum size.
5. The depth of any gravel layer should be not less than 2 in. nor less than twice the largest gravel size for that layer, whichever is greater. The bottom layer

TABLE 3

Typical Gravel Size and Layer Specifications

	Providence, R.I.	Metropolitan Water Dist., Calif.	Indianapolis Water Co. (Fall Creek)	Chicago	Mahoning Valley Dist., Ohio	Proctor, Vt.	Flat Rock, Mich.
Underdrain	3-in. laterals	4-in. laterals	false-bottom strainers	4-in. laterals	Wheeler bottom	2-in. laterals	porous plate
Orifice diam.	⅜ in.	½ in.		7/16 in.	¾ in.	½ in.	

Layer Thickness and Gravel Size—*in.*

Layer	Thickness	Size	Thickness	Size	Thickness	Size	Thickness	Size	Thickness	Size	Thickness	Size	Thickness	Size
Bottom	6	1–2	6	1½–2½	7	1–1½	6	1½–3½	3	½–¾	12*	1–2		
2nd	3	½–1	6	¾–1½	3	½–¾	4	¾–1½	3	⅜–½	4	½–1		
3rd	3	¼–½	4	½–¾	3	¼–½	2	½–¾	3	3/16–⅜	4	¼–½		
4th	3	⅛–¼	4	¼–½	3	#10–¼	3½	¼–½			3	⅛–¼		
5th							3½	⅛–¼						
Top	3	1/16–⅛	4	⅛–¼	3	#20–#10	2½	1/16–⅛	3	#12–3/16	3	1/16–⅛	3	0.8–1.2†
Total	18		24		19		21½		12		26		3	

* Deep layer required to cover 10-in. collector.
† Millimeters.

should be thick enough to cover underdrain laterals, strainers or other irregularities in the filter bottom.

6. The total depth of gravel above the underdrains should be not less than 12 in., except in filters with porous-plate underdrains where only one layer of fine gravel is sometimes used and frequently is omitted entirely.

As suggested by Baylis, a formula may be used for determining the depth of any given size of gravel below the bottom of the top gravel layer. For example, with a top gravel layer of 1.6-mm. ($\frac{1}{16}$-in.) diameter the formula is:

$$M = K \log D - 2.5$$

in which M is the depth in inches below the bottom of the top gravel layer; K is a coefficient taken as 11.63 to give a thickness of 3½ in. to gravel layers in which the smallest gravel has one-half the diameter of the largest; and D is the diameter of gravel at any depth M below the top gravel, which has a diameter of 1.6 mm.

The formula is obtained by drawing a straight line on semilogarithmic paper, through the $\frac{1}{16}$-in. diameter at the zero depth and the $\frac{1}{8}$-in. diameter at a depth of 3½ in. as shown in Fig. 1. Gravel layer thicknesses are determined from the graph or equation as in the following example:

Assume a gravel size of ⅜–⅝ in. (9.5–15.9 mm.). For $D = 9.5$ mm., $M = 9.0$ in.; for $D = 15.9$ mm., $M = 11.5$ in. The

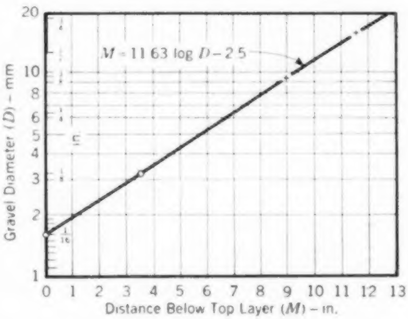


Fig. 1. Determining Gravel Depth

required layer thickness is $11.5 - 9.0 = 2.5$ in.

For other assumed top gravel sizes and layer thicknesses, a similar formula with different constants may be derived in the same manner.

This equation is used in determining the thickness of all layers of gravel ex-

TABLE 4

Grain Size Distribution, by Per Cent Size

Per Cent Size*	Grain Size—*mm.*					
	Fine		Medium		Coarse	
	Min.	Max.	Min.	Max.	Min.	Max.
1	0.26	0.32	0.34	0.39	0.41	0.45
10†	0.35	0.45	0.45	0.55	0.55	0.65
60†	0.53	0.75	0.68	0.91	0.83	1.08
99	0.93	1.50	1.19	1.80	1.46	2.00

* If the size distribution of the sand particles is such that 1 per cent of a sample is finer than 0.34 mm., the sand has a 1 per cent size of 0.34 mm.

† The ratio of the 60 per cent size to the 10 per cent size shall not exceed 1.70.

cept the bottom one, which is arbitrarily made of greater thickness, depending on the character of the underdrain system.

Note 2.5

Gravel is usually paid for in a lump sum or at a unit price per cubic yard in place or at a unit price per ton. The first two methods are preferable under contract work because they eliminate the possibility of dispute regarding excessive moisture, or loss or waste of gravel during shipment or placement.

Note 3.1

Where filters follow lime softening plants or filter relatively alkaline waters (pH of 8.0 or higher), or where operations over many years have demonstrated the satisfactory nature of a sand, acid solubility of the sand is of minor importance. If aggressive or low-pH waters are to be filtered, however, the acid solubility test is needed to exclude sand with harmful amounts of limestone or shells. In such waters, the solubility of the sand, determined as specified under Sec. A2.2 of the Appendix (p. 298), should not exceed 5 per cent.

Note 3.2

1. *Grade to be used.* Filter sands extending over a wide range of sizes have given satisfactory results. The grade of sand to be used in any particular filter cannot be specified without consideration

TABLE 5

Grain Size Distribution, by Sieve Size

Sieve Number		A.S.A. Sieve Opening *mm.*	Fine	Medium	Coarse
			Effective Size—*mm.*		
Tyler No.	U.S. No.		0.35–0.45	0.45–0.55	0.55–
			Per Cent Passing Sieve		
14	16	1.19	94–100	84–99	68–93
20	20	0.84	71–97	49–84	30–71
28	30	0.59	31–73	14–39	6–31
35	40	0.42	6–25	2–6	0–1
48	50	0.30	0–3	0–1	0

of local conditions and controlling factors. For purposes of definition in these specifications, the following limits have been established for the 10 per cent, or effective size: fine sand, 0.35 to 0.45 mm.; medium sand, 0.45 to 0.55 mm.; coarse sand, 0.55 mm. or larger. (If the size distribution of the sand particles is such that 10 per cent of a sample is finer than 0.45 mm., the sand has an effective size of 0.45 mm.)

In general, coarse sand will permit longer filter runs between washings than fine sand, and with good pretreatment facilities and close technical control will yield results adequate for most purposes. Coarse sand is less effective than fine in the removal of turbidity and bacteria.

Coarse sand is applicable when: [1] pretreatment is consistently good; [2] the highest degree of filtration is not required; [3] benefits from longer filter runs and less wash water offset any disadvantages from lower water quality; [4] filter design will permit the necessarily high backwash rates.

Fine sand is applicable when: [1] pretreatment is sometimes poor; [2] the maximum removal of turbidity is needed; [3] the maximum removal of bacteria is needed to safeguard health; [4] benefits of longer filter runs and lower wash water consumption are not of great importance; [5] backwash is limited by filter plant design to rates sufficient for cleaning fine sand only; [6] rapid buildup of grain size with calcium carbonate following softening is expected.

Medium sand is a compromise between the coarse and fine and is frequently suitable under average conditions.

2. *Grain size distribution.* Section 3.2 of the specifications includes alternate methods of defining sand size distribution. The first assigns limiting sizes to stated percentages by weight. For example: "The 10 per cent size shall be between 0.35 and 0.40 mm." Since the sieves will not separate the sand into fractions exactly equal to 1, 10, 60 and 99 per cent of the total weight, the sizes corresponding to these percentages must be interpolated from a plotting of the percentage of sample passing each sieve against the separation size of that sieve. The plotting is best made on logarithmic-probability paper (see Fig. 2), but semilog plotting can be used if probability paper is not available.

The second method of classification defines the percentage of sand that shall be finer than stated grain sizes. For example: "The percentage of sand finer

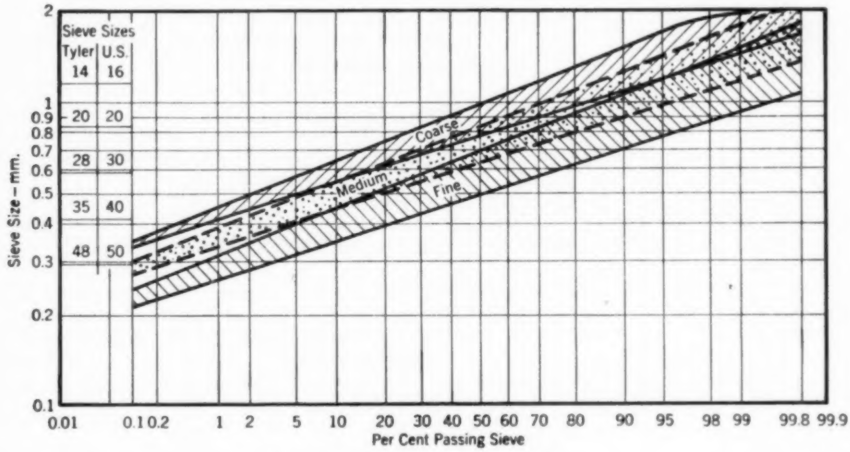


FIG. 2. Grain Size Distribution

than 0.4 mm. shall be between — per cent and – per cent of the total." By fixing percentages that correspond to the separation sizes of standard sieves, the results of a sieve analysis can be used directly without plotting.

Typical specifications for fine, medium and coarse sands are given in Table 4. size; [3] the 99 per cent size does not exceed 2 mm. or 4 times the 10 per cent size, whichever is smaller.

The grading of the three sands, specified according to sieve sizes, is given in Table 5. Limiting values for the three grades are plotted on logarithmic-probability paper in Fig. 2. The plotting

TABLE 6

Typical Sand Size Specifications

Plant	10% Size		Max. Ratio 60% size / 10% size	Other Size Requirements
	Min. *mm.*	Max. *mm.*		
Chicago (1946)	0.62	0.70	1.50	1%, 0.485–0.550 mm.; 2%, 0.520–0.590; 4%, 0.560–0.630; 8%, 0.600–0.680; 16%, 0.650–0.745; 32%, 0.720–0.840
Detroit (1931)	0.45	0.50	1.40*	30%, 0.50–0.60 mm.; 90%, 0.75–1.15; 98%, 1.00–1.70; 100% to pass 2.0-mm. opening; 100% to be retained on Tyler 48-mesh sieve (penalties provided for minor deficiencies)
Metropolitan Water Dist., Calif. (1939)	0.45	0.50	1.65	(20-in. sand layer supported on 4-in. layer of coarse material, with 10% size between 1.0 and 1.5 mm.)
Kansas City (1925)	0.40	0.50	1.65	Not over 0.2% to be finer than 0.20 mm.; not over 1.0% to be finer than 0.25 mm.; not less than 90% to be finer than 0.80 mm.
Mahoning Valley Dist., Ohio (1930)	0.38	0.42	1.60	Same as for Kansas City; also, not less than 28% nor more than 32% to be finer than 0.50 mm. (21-in. sand layer supported on 6-in. coarser sand layer, with 10% between 1.0 and 1.5 mm.)
Providence, R.I. (1924)	0.35	0.40	1.60	Not less than 95% to be finer than 1.00 mm.; 100% to be finer than 2.00 mm.

* Minimum, 1.20.

These specifications will meet ordinary requirements. However, there are other intermediate sand sizes and sands with more uniform size distribution which will work fully as well, and a sand should not be rejected simply because it falls outside the ranges noted. A well graded sand of the approximate desired effective size will be satisfactory if: [1] the 1 per cent size is not less than 0.5 times the 10 per cent size; [2] the 60 per cent size does not exceed 1.7 times the 10 per cent of sieve sizes is based on nominal openings, not on actual separation size.

Where closer limits for sand size distribution are required, the ranges may be made narrower than those noted and the sizes may be specified for more points along the curves.

Sand size specifications for various plants are shown in Table 6.

3. *Calibration of sieves.* The approved method for calibrating sieves is described fully in Sec. A2.4 of the Appendix (p.

298). Attention is directed to the method of rating sieves against a standard set of sieves described therein, which requires much less time and effort than the original method of counting and weighing sand grains.

The actual separation sizes of the most accurate sieves available today frequently vary from the manufacturers' ratings and stated openings. In general, over the range normally used in testing filter sands, the equivalent diameter of separation is approximately 1.1 times the rated opening. Continued use of sieves will cause a gradual increase in the actual size of separation. The results of analyses with uncalibrated sieves are of limited accuracy, and close comparison with results obtained elsewhere with another set of sieves is impossible. However, great accuracy is not usually needed in the selection of sand, and variations in sieve openings are normally less than the tolerances allowed in sand specifications.

Purchasers requiring that calibrated sieves be used should so specify in Sec. 3.2.

APPENDIX

Section A1—Other Filtering Materials

The removal of turbidity and bacteria by a filter is affected not only by the grain size, but also by the particle shape. Sharp, angular particles produce larger voids and do not remove as much material as rounded particles of the same equivalent diameter.

Comparable filtering results will be obtained with several types of materials meeting approximately the size ratios and porosity percentages noted in Table A1.

TABLE A1

Relative Size and Approximate Porosity

Material	Relative Particle Size	Approx. Porosity *per cent*
Rounded sand	1.00	40–45
Rounded anthracite or rough sand	0.90	45–50
Crushed quartz or crushed anthracite	0.73	50–55

The grading from coarse to fine can be similar regardless of the material used, and the standard specifications can be applied with minor modifications.

Anthracite coal is sometimes used to advantage in place of sand or gravel. For successful operation, the anthracite coal should be obtained from an approved source; must be clean, and free from long, thin or scaly pieces; and should have a hardness of 3.0 to 3.75 on the Moh scale and a specific gravity of not less than 1.55.

The principal advantages of anthracite are as follows:

1. Because of its low specific gravity, coal can be backwashed at about two-thirds the rate required for sand; wash water facilities of lower capacity can be used. This may be of considerable value in the renovation of old filters in which the underdrain system is inadequate for the proper backwashing of sand.

2. Coal is insoluble in acid or caustic as normally encountered, and water passing through a coal filter will not pick up silica.

3. The surface of the coal particles is such as to resist better than sand some encrustations and grease accumulations.

If layers of coal and sand are used in the same filter, the coal layer must be on top of the sand, and not vice versa, to prevent mixing caused by differences in specific gravity.

Crushed quartz has been used to only a limited extent in water works practice.

Section A2—Test Procedures

Sec. A2.1—Sampling

Samples of gravel shall be not less than $\frac{1}{3}$ cu.ft. for sizes $\frac{1}{2}$ in. or larger, and not less than 1 qt. each for all smaller sizes. At least one sample shall be taken from each carload or each 30 cu.yd. of gravel.

Sand samples shall be not less than 1 qt., and one sample shall be taken from each 10 cu.yd.

Samples shall be furnished in clean, dust-tight receptacles, carefully labeled as to source and date of sampling. The samples shall be quartered or riffled to suitable size for analysis.

Sec. A2.2—Acid Solubility

Samples shall be not less than 10 g. for sand and fine gravel, and for gravel 1 in. and larger shall contain not less than ten representative particles. The test procedure is as follows:

Rinse the sample with distilled water to remove all dust and fine material, dry and weigh. Immerse the sample in 40 per cent (by volume) HCl (prepared by diluting four volumes of concentrated HCl—specific gravity 1.18–1.20—to ten volumes with distilled water) for a period of 24 hours at room temperature (between 65° and 75°F.). After 24 hours thoroughly rinse the sample with distilled water, dry and weigh. The percentage of solubility is given by the formula:

$$\text{Solubility } (\%) = \frac{\text{Loss in weight}}{\text{Original weight}} \times 100$$

Sec. A2.3—Gravel Porosity

An open container of known volume, not less than $\frac{1}{3}$ cu.ft. for material over 1 in., and $\frac{1}{10}$ cu.ft. for finer material, shall be filled completely with the material to be tested. The container and material shall be agitated during filling to assure compaction. (The volume of the container equals C.) The voids shall be filled completely with water by pouring from a graduated cylinder or other measuring device. The water shall be added slowly to assure escape of all trapped air. (The volume of water added equals V.) The porosity, in per cent, is given by the formula:

$$\text{Porosity } (\%) = V/C \times 100$$

Sec. A2.4—Sand Porosity

The porosity of sand may be determined with a volumetrically graduated Jackson turbidimeter tube, 75 cm. long and approximately 2.8 cm. in diameter. The procedure is as follows:

Pour a weighed sample (w) of approximately 150 g. of sand into the Jackson tube, which is half full of water. Shake the contents to remove entrained air from the sand. If the water appears dirty, decant and repeat until the sand is clean and free from air. Take care not to lose sand while decanting.

Fill the tube completely with water and stopper. Mount the tube in a clamp assembly on a laboratory supporting stand so that the tube can be rotated about an axis at right angles to the tube length. Place a rubber pad under the bottom of the tube, which is now clamped firmly just above the middle.

Rotate the tube through 180 deg. and allow the entire sand sample to settle to the cork. Keep the cork tight. Quickly invert the tube again, right side up, with the bottom resting upon the rubber pad. The tube should be righted and firmly in place before the first grains of sand have settled upon the bottom; the entire column is allowed to settle with the operator standing clear of the apparatus. Read the volume (v) of sand immediately. (The Jackson turbidimeter method of determining porosity gives results 1 or 2 per cent higher than those obtained in test filters.) The porosity, in per cent, for silica sand with a specific gravity of 2.65, is given by the formula:

$$\text{Porosity } (\%) = \frac{v - \dfrac{w}{2.65}}{v} \times 100$$

Sec. A2.5—Calibration of Sieves

The entire statement of "Calibration of Sieves" contained in the *Manual of Wa-*

ter Works Practice is reproduced here because the method is still valid and the *Manual* is no longer in print or generally available:

Sieves are made from carefully selected brass wire cloth having as nearly as possible square and even sized meshes. The frames are of metal, fitting one to another and the last to a pan at the bottom so that there will be no loss of material. The wire cloth may be bought in large pieces, carefully inspected and a number of sets of sieves made as nearly as possible alike from these pieces. A serial number is stamped on each sieve in small figures for permanent record. After the size of separation is determined, as described below, that size should also be stamped on it but in larger and more conspicuous figures.

The dimensions of wire cloth recommended by the Bureau of Standards are shown in the JOURNAL (Jour. A.W.W.A., **5**: 345 (1918)).[A1]

It has not been found possible to get a number of sieves that will give exactly the same size of separation. Even among sieves made from the same piece of wire cloth there will be variations. A great deal of time and ingenuity has been spent in trying to make the sieves interchangeable. An approximation to this result can be accomplished; but it is not necessary and if accomplished would make no material change in present methods or results.

With the mass system of plotting the line resulting from plotting the analysis of a given sample made by any rated sieves should be the same within reasonable error limits as that resulting from the use of any other rated set.

The number of sieves to be used and the relation between their sizes of separation have been frequently discussed. The requirements vary according to the kind of sand and the purposes for which it is to be used. In examining bank sands and sands for sand filters having uniformity coefficients of 2.5 and over, a set of sieves in which there is a ratio of approximately 2 to 1 between sizes of separation of each sieve and the next will answer. In examining even grained sands with uniformity coefficient under 2.0, such as are used in mechanical filters, at least one intermediate sieve, between each two such sieves, is needed. In some offices screen openings having a ratio of the $\sqrt{2}$ to each other are preferred. The greatest interest in filter sand will be as to the size of particles ranging from 0.30 to 0.60 mm. and two or three extra sieves in this range will be helpful. A liberal number of sieves in a set is advantageous; but in any particular analysis, only those sieves necessary to the purpose in hand should be used. It will never be necessary to use the whole of a full set at one time. A set of sieves can frequently be split into two sets, putting every alternate sieve in one set and the other in another. Such split sets will be ample for many purposes, and it should make no material difference in the results which of the two sets is used.

Specifications for sieves have been prepared by the United States Bureau of Standards and by the American Society for Testing Materials.

The finest wire cloth available for making sieves has about 200 meshes per lineal inch and the size of separation found for it is usually between 0.100 to 0.110 mm. That cloth and one of the two of the next coarser sizes, are woven with a twill, two over and two under and have quite different sifting qualities from coarser cloth woven, one over and one under.

The coarsest wire mesh to be used has 20 meshes per inch. All coarser sieves are better made from perforated metal plates. These are more uniform and satisfactory than large mesh wire cloth.

Sieves are surprisingly durable when carefully handled; but it is well to recheck the rating at intervals. Leaks sometimes develop, and these are disclosed by rerating. Leaks may result from accidents to the cloth which enlarge some of the holes, or the cloth may get loose from the metal sides of the sieves. In either case the leaks can be stopped by solder; and it is a good plan to go over old sieves occasionally with a soldering iron, closing possible points of leakage.

Irregularities in Plotting

An irregular line, that is to say, one with sharp bends either up or down, shows badly rated sieves or defective methods of sifting. If sieves do not show good consistent plottings with fairly direct lines, the rating and

[A1] Since the publication of this material in the JOURNAL, the American Standards Association has developed "Standard Specifications for Sieves for Testing Purposes—ASA Z23.1–1939." This is available from the A.S.A., 70 East 45th St., New York, N.Y., at 25 cents per copy. Table 1 from that document is reproduced herewith as Table A2.

TABLE A2

(Table 1 From ASA Z23.1–1939)

Nominal Dimensions, Permissible Variations, and Limits for Woven Wire Cloth of Standard Sieves

Size or Sieve Designation	Sieve Opening		Permissible Variations in Average Opening, *per cent*	Permissible Variations in Maximum Opening,[a] *per cent*	Wire Diameter	
	mm.	*in.* (approx. equivalents)			*mm.*	*in.* (approx. equivalents)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coarse Series						
(4.24-in.)**	107.6	4.24	±2	+3	5.6 to 9.7	0.220 to 0.380
4-in.	101.6	4.00	±2	+3	5.6 to 9.7	0.220 to 0.380
3½-in.	88.9	3.50	±2	+3	5.3 to 9.3	0.210 to 0.365
3-in.	76.2	3.00	±2	+3	4.8 to 8.1	0.190 to 0.320
2½-in.	63.5	2.50	±2	+3	4.4 to 7.1	0.175 to 0.280
(2.12-in.)**	53.8	2.12	±2	+3	4.1 to 6.2	0.160 to 0.245
2-in.	50.8	2.00	±2	+3	4.1 to 6.2	0.160 to 0.245
1¾-in.	44.4	1.75	±2	+3	3.8 to 5.7	0.150 to 0.225
1½-in.	38.1	1.50	±2	+3	3.7 to 5.3	0.145 to 0.210
1¼-in.	31.7	1.25	±2	+3	3.5 to 4.8	0.140 to 0.190
(1.06-in.)**	26.9	1.06	±3	+5	3.43 to 4.50	0.135 to 0.177
1-in.	25.4	1.00	±3	+5	3.43 to 4.50	0.135 to 0.177
⅞-in.	22.2	0.875	+3	+5	3.23 to 4.22	0.127 to 0.166
¾-in.	19.1	0.750	±3	+5	3.10 to 3.91	0.122 to 0.154
⅝-in.	15.9	0.625	±3	+5	2.74 to 3.43	0.108 to 0.135
(0.530-in.)**	13.4	0.530	±3	+5	2.39 to 3.10	0.094 to 0.122
½-in.	12.7	0.500	±3	+5	2.39 to 3.10	0.094 to 0.122
7/16-in.	11.1	0.438	±3	+5	2.23 to 2.84	0.088 to 0.112
⅜-in.	9.52	0.375	±3	+5	2.11 to 2.59	0.083 to 0.102
5/16-in.	7.93	0.312	±3	+5	1.85 to 2.36	0.073 to 0.093
(0.265-in.)**	6.73	0.265	±3	+5	1.60 to 2.11	0.063 to 0.083
¼-in. (No. 3)	6.35	0.250	±3	+5	1.60 to 2.11	0.063 to 0.083
Fine Series						
5660 micron (No. 3½)	5.66	0.223	±3	+10	1.28 to 1.90	0.050 to 0.075
4760 micron (No. 4)	4.76	0.187	±3	+10	1.14 to 1.68	0.045 to 0.066
4000 micron (No. 5)	4.00	0.157	±3	+10	1.00 to 1.47	0.039 to 0.058
3360 micron (No. 6)	3.36	0.132	±3	+10	0.87 to 1.32	0.034 to 0.052
2830 micron (No. 7)	2.83	0.111	±3	+10	0.80 to 1.20	0.031 to 0.047
2380 micron (No. 8)	2.38	0.0937	±3	+10	0.74 to 1.10	0.0291 to 0.0433
2000 micron (No. 10)	2.00	0.0787	±3	+10	0.68 to 1.00	0.0268 to 0.0394
1680 micron (No. 12)	1.68	0.0661	±3	+10	0.62 to 0.90	0.0244 to 0.0354
1410 micron (No. 14)	1.41	0.0555	±3	+10	0.56 to 0.80	0.0220 to 0.0315
1190 micron (No. 16)	1.19	0.0469	±3	+10	0.50 to 0.70	0.0197 to 0.0276
1000 micron (No. 18)	1.00	0.0394	±5	+15[a]	0.43 to 0.62	0.0169 to 0.0244
840 micron (No. 20)	0.84	0.0331	±5	+15[a]	0.38 to 0.55	0.0150 to 0.0217
710 micron (No. 25)	0.71	0.0280	±5	+15[a]	0.33 to 0.48	0.0130 to 0.0189
590 micron (No. 30)	0.59	0.0232	±5	+15[a]	0.29 to 0.42	0.0114 to 0.0165
500 micron (No. 35)	0.50	0.0197	±5	+15[a]	0.26 to 0.37	0.0102 to 0.0146
420 micron (No. 40)	0.42	0.0165	±5	+25[a]	0.23 to 0.33	0.0091 to 0.0130
350 micron (No. 45)	0.35	0.0138	±5	+25[a]	0.20 to 0.29	0.0079 to 0.0114
297 micron (No. 50)	0.297	0.0117	±5	+25[a]	0.170 to 0.253	0.0067 to 0.0100
250 micron (No. 60)	0.250	0.0098	±5	+25[a]	0.149 to 0.220	0.0059 to 0.0087
210 micron (No. 70)	0.210	0.0083	±5	+25[a]	0.130 to 0.187	0.0051 to 0.0074
177 micron (No. 80)	0.177	0.0070	±6	+40[a]	0.114 to 0.154	0.0045 to 0.0061
149 micron (No. 100)	0.149	0.0059	±6	+40[a]	0.096 to 0.125	0.0038 to 0.0049
125 micron (No. 120)	0.125	0.0049	±6	+40[a]	0.079 to 0.103	0.0031 to 0.0041
105 micron (No. 140)	0.105	0.0041	±6	+40[a]	0.063 to 0.087	0.0025 to 0.0034
88 micron (No. 170)	0.088	0.0035	±6	+40[a]	0.054 to 0.073	0.0021 to 0.0029
74 micron (No. 200)	0.074	0.0029	±7	+60[a]	0.045 to 0.061	0.0018 to 0.0024
62 micron (No. 230)	0.062	0.0024	±7	+90[a]	0.039 to 0.052	0.0015 to 0.0020
53 micron (No. 270)	0.053	0.0021	±7	+90[a]	0.035 to 0.046	0.0014 to 0.0018
44 micron (No. 325)	0.044	0.0017	±7	+90[a]	0.031 to 0.040	0.0012 to 0.0016
37 micron (No. 400)	0.037	0.0015	±7	+90[a]	0.023 to 0.035	0.0009 to 0.0014

** The five sieves marked in the first column with a double asterisk (**) may be used instead of the 4-in., 2-in., 1-in., ½-in., and ¼-in. sieves when it is desired to have a series of sieves nesting with the Fine Series and continuing that series with the $\sqrt[4]{2} : 1$ ratio. All of the other sieves listed above are in $\sqrt[4]{2} : 1$ ratio with the Fine Series within the limit of the specified permissible variations. Care should be taken in designating the five sieves marked with the double asterisk; they should not be designated as 4-in., 2-in., 1-in., ½-in., and ¼-in., but as 4.24-in., 2.12-in., 1.06-in., 0.530-in., and 0.265-in. (or by the manufacturer's nominal values, for example, for the last three 1.050-in., 0.525-in., and 0.263-in.).

[a] For sieves from the 1000-micron (No. 18) to the 37-micron (No. 400) size, inclusive, not more than 5 per cent of the openings shall exceed the nominal opening by more than one-half of the permissible variation in maximum opening.

methods of sifting ought to be at once investigated. Inadequate shaking or a leak may be the cause. Some irregularity at the upper end is unavoidable, because with 50 or 100 gram samples, a single particle weighs so much as to make a difference in the plotting at the top. Such irregularities must be passed as of no significance.

The curvature of the line at the bottom is of fundamental importance. When a line bends down at the fine end of the regular plotting (or up on probability paper), it means that the fine material has been removed, usually by washing or some artificial process so that it is unusually free from small particles and is cleaner than normal sand. When the line at the bottom curves upward on the regular plotting (or downward on probability paper), it indicates that there is an excess of fine particles such as might, for instance, be found in a sand in a filter resulting from accumulation of particles taken from the water being filtered. In general, a normal sand gives a direct line to the end and in some cases almost a straight line.

Definition of Size of Grain

The size of grain of granular material is defined as the diameter of a sphere of equal volume.

The size of grain is always the ultimate standard. The size of mesh or opening is not to be substituted for it.

When sieves with rectangular or round openings are used and with all other methods of separation, the method should be tested out as far as possible to ascertain the actual size of separation for that particular sieve or procedure and the result should be stated in grain size rather than in terms of sieve openings. The reasons for this will be stated below.

At Lawrence, Mass., it was found, as the average of numerous measurements, that the three axes of the grain, selecting the longest possible and taking the other two at right angles to it, are as 1.38, 1.05, and 0.69 to the mean diameter. The cube root of their product is a close approximation to the mean.

Rating

It can be easily shown by experiment that, when a mixed sand is shaken upon a sieve, the smaller particles pass most rapidly at first and as the shaking is continued, after the smaller particles are all out, larger particles pass until a limit is reached when almost nothing more will pass. The last and largest particles passing represent the separation of that sieve. Practically all of the material that passes in the usual analysis is finer than these last particles and practically everything that remains is coarser.

The size of separation of a sieve bears some relation to the size of mesh; but the relation varies and is not to be depended upon. There are unavoidable irregularities of the meshes in individual sieves. Moreover, particles passing the finer sieves are larger in proportion to the mesh size than is the case with coarser sieves. For these reasons the actual sizes of separation are determined by actual measurement. Elaborate measurements of meshes and wires are unnecessary and do not contribute to the accuracy of the final result.

In rating a set of sieves a representative sand sample, preferably with a uniformity coefficient that is not too low, is put in the sieves and the process of shaking is carried out precisely as it would be in an ordinary analysis. The sieves are then taken apart for further examination one at a time. If the sample taken for this purpose is of such grain size that some sieves show but little material left on them, these sieves should be discarded for the present purpose and tested further with another sample better adapted to their rating. Sieves that have a substantial amount of sand left on them are taken one at a time and given a certain further amount of shaking. The small amount of material collected in the pan from this additional shaking will all of it be of particles of nearly the same size.

The size of these particles is now to be determined. The procedure is to count out a considerable number of them and to weigh them and to determine their size from their average weight. The size is the diameter of a sphere of equal volume. When the weight and specific gravity are known the diameter can be calculated.

The volume of a sphere is $\frac{1}{6}\pi D^3$. It is also equal to the weight divided by the specific gravity. The weights are stated in milligrams and the diameters in millimeters. The specific gravity of sand ordinarily used averages 2.65. Very few sands fall below 2.6 or above 2.7. It is well to determine the actual specific gravity of the particles of the sand being used; but in most cases 2.65 may be used. Where this is the case it is computed that $D = 0.9\sqrt[3]{W}$. The exact co-

efficients are: for specific gravity 2.60, 0.9023; for 2.65, 0.8966; for 2.70, 0.8910. A line drawn on 20 inch base logarithmic paper can be conveniently used for conversion, or the calculation may be made by a log slide rule.

An accurate balance for weighing the particles is necessary. The counting is best carried out by putting a small sample of sand on paper ruled in squares, covered and placed where it cannot be disturbed during the process of counting. Every sieve should be rated at least three times, preferably with different kinds of sand, and consistent results obtained before they are accepted.

The number of particles to be counted will hardly be less than 100 in any case. One hundred particles 0.4 mm. in diameter will weigh 8.8 milligrams and it will take a delicate balance to weigh these with sufficient accuracy.

For the finer sieves the number of particles that must be counted will be larger, running up to several thousand for the 200 mesh sieve. In a general way the sieves most important in filtration, 0.2 mm. and upward, will not require the counting of numbers so large as to be unduly burdensome.

For the two or three finer sieves in each set the rating by counting is more tedious and it will be better to rate a few such sieves with the utmost care and depend upon indirect or comparative rating (to be presently described) for the others.

Effect of Shape of Grains Upon Rating

The shape of the grains whether round, oval or angular makes some difference in the rating of the sieves. This matter was tested out by making 50 ratings of sieves ranging from 0.134 to 1.03 mm., or from 140 to 20 meshes per inch, with different kinds of sand. The work was done years ago by two men working independently. Several samples of each of five kinds of sand were used. Each sieve was rated on all the different kinds of sand and the average rating from all determinations taken. The relative rating with each particular kind of sand was then calculated for each sieve and these were averaged for all sieves. The average results were as shown on Table A3.

From this it appears that sand that is somewhat worn and rounded gives a slightly lower rating to a sieve than either completely rounded or entirely angular grains.

TABLE A3

Kind of Sand Used in Rating	Rating in Terms of the Mean of All
Red Wing, Minn., wind worn and almost spherical	1.012
New Jersey Sea Shore, water worn and considerably rounded	1.000
Allegheny River, originally glacial drift, but water worn	0.982
Masscahusetts Bank sand, glacial drift, sharp grained	1.004
Crushed quartz, entirely angular	1.007

The entire range in results is small and not of much practical importance.

Relation Between Mesh Size and Size of Separation

The following represents approximately the relation between commercial brass wire cloth and the sizes of separation.

Meshes per in.	200	140	100	50	40	30	20
Separation in mm.	0.10	0.13	0.17	0.33	0.48	0.63	0.95

The results will vary either way from these values, which are only given as an aid in selecting proper cloth for sets of sieves.

Width of Mesh or Grain Size

It has been proposed at various times that sieves should be made with wire cloths of standard mesh, all dimensions being most carefully defined, and that such carefully made sieves should be used without rating. In this case the size of the mesh would be substituted for the grain size. This procedure has been largely adopted for sand to be used for concrete and other purposes.

Philip Burgess (Jour. A.W.W.A., **2**: 493 (1915)) sets forth the advantage of this procedure. In the discussion that followed is a statement (p. 504) of the advantages of adhering to the grain size as a basis for classification. This statement is referred to for further particulars. Both of these papers were reprinted (*Engineering Record*, **71**: 644). The Committee Report of 1918 (p. 543) contains further particulars of the sieves recommended by the Bureau of Standards, but no further discussion on the main question.

Other proposals for simplifying sand analyses and methods for stating results have been made from time to time. The "fineness

modulus" method developed by Abrams should be here mentioned. The Committee Report of 1924 (Jour. A.W.W.A., **11**: 677 (1924)) should be consulted for interesting discussions of this and other possible modifications of auxiliaries to existing methods.

Comparative Rating

When sieves were first rated by weighing and counting particles at Lawrence, Mass., duplicate sieves were made and rated with the utmost care and in the thirty-five years since that time, one set of these sieves has been kept by one worker for the sole purpose of comparing with other sieves. In other words this set has been reserved as a control standard. It has been found possible, by using these and other carefully rated sieves, to obtain comparative ratings of value.

The method used is to take two old and very carefully standardized sets of sieves, such as the one above mentioned and another and ten new and untested sets of sieves. One hundred grams of sand suitable for this use are taken. These same 100 grams are put through each of the 12 sets of sieves in succession and the separations recorded. With careful manipulation the loss of material in the twelve siftings is not enough to be of importance. It should not exceed at most half a gram; but to eliminate any error that might be introduced in this way, the process is at once repeated with another sample of sand, the same sets of sieves being used: but this time in reverse order. The analyses of each sand sample taken for these tests are plotted on a special sheet of paper of much larger scale than is used in routine work. Logarithmic paper on 20-inch base is appropriate. The analysis is first plotted from the two sets of rated sieves. The results from these must be consistent and plot in a direct line. From this line and the per cents passing all the other sieves, the corresponding sizes of separation are ascertained. This process is ordinarily repeated several times so that at least three comparative figures for each sieve are obtained. With well selected samples and careful manipulation consistent and accurate results are secured. The method is a delicate one; but it is, of course, applying in an indirect way the results of the direct rating of the primary sieves.

Section A3—Bibliography

This bibliography is composed of the references listed by H. E. Hudson Jr. in an appendix to the Committee Progress Report on Specifications for Filtering Material (November 1941 JOURNAL, Vol. 33, p. 2021) with additions to date.

1. HAZEN, ALLEN. Some Physical Properties of Sands and Gravels. Mass. State Board of Health Rept. (1892), p. 542.
2. KING, F. H. A New Method for the Mechanical Analysis of Soils. Univ. of Wis. Expt. Sta., 15th Ann. Rept. (1898).
3. ———. Principles and Conditions of the Movements of Ground Waters. U.S. Geol. Survey 19th Ann. Rept., Part II (1899), p. 59.
4. SLICHTER, C. S. Theoretical Investigation of the Motion of Ground Waters. U.S. Geol. Survey 19th Ann. Rept., Part II (1899), p. 295.
5. HAZEN, ALLEN. The Filtration of Public Water Supplies. John Wiley & Sons, New York. (3rd ed., 1903).
6. BALDWIN-WISEMAN, W. R. Statistical and Experimental Data on Filtration. Min. Proc. Inst. Civ. Engrs., **181**:15 (1909–10).
7. HAZEN, ALLEN. The Flow of Underground Water Through Sand, Gravel, etc. Trans. A.S.C.E., **58**:176 (1911).
8. BURGESS, PHILIP. Mechanical Analysis of Sands. Jour. A.W.W.A., **2**:493 (1915).
9. Progress Report of Committee on Mechanical Analysis of Sands. Jour. A.W.W.A., **5**:345 (1918).
10. Progress Report of Committee on Filter Sand Analysis. Jour. A.W.W.A., **11**: 677 (1924).
11. Progress Report of Committee on Filtering Materials. Jour. A.W.W.A., **14**:235 (1925).
12. TERZAGHI, CHARLES. Principles of Soil Mechanics. Eng. News-Rec., **95**:832 (1925).
13. TYLER, R. G. A Fineness Modulus for Filter Sands. J.N.E.W.W.A., **39**:239 (1925); **40**:24 (1926).
14. STEARNS, N. D. Laboratory Tests on the Physical Properties of Water-bearing Materials. U.S. Geol. Survey, Water Supply Paper No. 596 (1927).

15. Filter Sand. *Editorial.* Eng. News-Rec., **105**:873 (1930).
16. Armstrong, James W. Filter Sand. Jour. A.W.W.A., **23**:1292 (1931).
17. Stanley, W. E. Filtering Materials for Water Works. Jour. A.W.W.A., **23**: 1283 (1931).
18. Report of the Committee on Filtering Materials. Jour. A.W.W.A., **24**:1316 (1932).
19. Hulbert, R. & Feben, D. Hydraulics of Rapid Filter Sands. Jour. A.W.W.A., **25**:19 (1933).
20. Turner, H. G. & Scott, G. S. *Discussion*—Hydraulics of Rapid Filter Sands. Jour. A.W.W.A., **25**:55 (1933).
21. Hulbert, R. & Feben, D. An Improved Method for Measuring Porosity of Sand. Jour. A.W.W.A., **26**:771 (1934).
22. Black & Stutz. Physical Factors Affecting the Hydraulic Properties of Rapid Filter Sands. Master's Thesis, Univ. of Illinois (1933).
23. Fair, G. M. & Hatch, L. P. Fundamental Factors Governing the Streamline Flow of Water Through Sand. Jour. A.W.W.A., **25**:1551 (1933).
24. Harmeson & Hasfurther. Physical Conditions Affecting the Flow of Water Through Nonstratified Sand. Master's Thesis, Univ. of Illinois (1934).
25. Baylis, J. R. A Study of Filter Materials for Rapid Sand Filters. Parts II, III & VI. Wtr. & Sew. Wks., **81**: 162, 352 (1934); **82**:327 (1935).
26. Farrell, M. A. & Turner, H. G. Fine Anthracite and Sand. W.W. Eng., **84**:1673 (1931).
27. Farrell, M. A. The Use of Anthracite Coal as a Filter Medium. Jour. A.W.W.A., **25**:716 (1933).
28. Turner, H. G. & Scott, G. S. Clarification of Water Supplies by Filtration Through Anthracite. Wtr. & Sew. Wks., **80**:330 (1933).
29. Hoover, C. P. Experience With Anthracite Coal as a Filter Medium for Water Softening. Wtr. & Sew. Wks., **80**:394 (1933).
30. Ripple, O. J. Anthracite and Sand as a Filter Medium. W.W. Eng., **88**:277 (1935).
31. ———. Experience With Anthracite as a Filter Medium. Wtr. & Sew. Wks., **83**:255 (1936).
32. Allan, L. F. Filter Sand Experiments. Jour. A.W.W.A., **27**:205 (1935).
33. Progress Report of the Committee on Filtering Materials. Proc. A.S.C.E., **62**:1543 (1936).
34. Eliassen, Rolf. Clogging of Rapid Sand Filters. Jour. A.W.W.A., **33**: 926 (1941).
35. Baylis, J. R. Experiences in Filtration. Jour. A.W.W.A., **29**:1010 (1937).
36. Smith, M. C. Raw Water Preparation *vs.* Filter Design. Wtr. & Sew. Wks., **83**:351 (1936).
37. Tiemersma-Wichers, C. M. & Jacobs, E. Tests for Sand and Gravel. Water (Neth.), **75**:99 (1939); *abstracted* Jour. A.W.W.A., **31**:1618 (1939).
38. Riddick, T. M. Filter Sand. Jour. A.W.W.A., **32**:121 (1940).
39. McCall, G. B.; Edwards, S. E. & Hopkins, Edward S. Effectiveness of Sand Filters in Removing Floc. Jour. A.W.W.A., **32**:147 (Jan. 1940).
40. Gerrard, H. J. Filter Sand—From a Producer's Standpoint. Jour. A.W.W.A., **32**:152 (Jan. 1940).
41. Hulbert, Roberts. The Filter Backwash—Sand Expansion and Velocity. Jour. A.W.W.A., **34**:1045 (July 1942).
42. Lauter, Carl J. The Fundamentals of a Properly Designed and Properly Operating Filter. Jour. A.W.W.A., **34**:1051 (July 1942).
43. Tentative Standard Specifications for Filtering Material—SC-T. Jour. A.W.W.A., **35**:455 (April 1943).
44. Turner, H. G. Anthrafilt and Its Significance. Jour. A.W.W.A., **36**:431 (April 1944).

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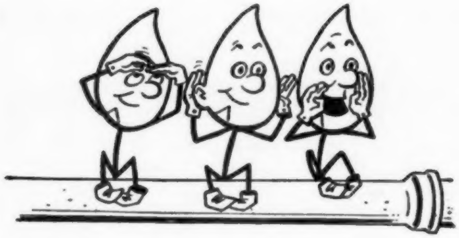

Percolation and Runoff

We wish ourselves a happy 68th birthday! Now that we're by way of qualifying for membership in the Austere Society of Septuagenarian Sages, we're becoming less and less touchy about our anniversaries and more and more conscious of the values of venerability. Thus, though our last year's checkup (*see* text pages 261–2) proved that we're still a growing boy, it behooves us now to assert our ancience and so establish our claims to the respect due our seniority:

A.W.W.A. was born on March 29, 1881, at Engineers' Hall, Washington Univ., St. Louis, Mo., weighing in at 24 members. Although virtually contemporaneous, N.E.W.W.A. did not see the light of day until more than a year later, on June 21, 1882. And to internationalize these facts of life, we extend the record to our British friends, reporting: 1896 as the birth date of the Institution of Water Engineers, the industry's technical group; 1911, of the British Water Works Association, composed of management personnel; and 1946, of the Association of Water Works Officers, a group of water works staff officials.

Certainly these facts should put us in our place. And if our age be insufficient to time-honor us in your view, give greeting at least to the apparent absence of senility or decrepitude.

But speaking of age and time:

The Atomic Hour has struck! No longer are we dependent upon the erratic revolution of the Earth to tell us when we can close up our desks at night; now we can gage our efforts by the infinitely, if imperceptibly, more stable dictates of the atomic clock.

When the Atomic Age was ushered in some time ago, we gave it as cordial a welcome as our confused cautiousness would permit. When bigger A-bombs, guided missiles, supersonic planes and bases in the stratosphere were announced, we tut-tutted our trepidation as ignorance and took refuge in Junior's comic strips. But when National Bureau of Standards' scientists brought us back to earth again with an atomification we could almost understand, we took heart and allowed ourselves to examine the implications.

It became immediately obvious, of course, that the revolutions of the Earth could not be considered dependable, varying as they do by as much

(*Continued on page 2*)

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as one part in twenty to thirty million from day to day, and slowing down at a rate of about 0.002 second per century. And we went along with the Bureau scientists in substituting the constant vibrations of the atoms in ammonia molecules as a base, when we learned that their variation in clocking could be reduced to about one part in a hundred million. But once we got that far, we wondered if we shouldn't go back to *Buck Rogers* and *Superman.*

Consider for a moment what our adoption of atomic time will mean. If, for instance, the current rate of rotational slowdown is maintained—and there is no reason to suppose that the drag of the tides will subside—we must look forward to a 25-hour atomic day in 1,800,000 centuries—a mere matter, understand, of 65,745,000,000 days. Granted that we shall be able by that time to realign our present units of measurement, such as mgd., and even that we shall be able to use the extra hour of sleep by then, but what of the interim? Are we going to keep abreast of the extended day by making constant changes in those units; are we going to have a 24¼- and then a 24½-hour clock; and how are we going to know when to celebrate the New Year? Even much more worrisome than that, why should we accept the present Earth-bound hour as standard? Why not go back to the beginning of Time, or of the calendar at least, and give us now the benefit of a few more minutes leisure per day? No, we fear there must be something subversive about anything so difficult to understand. Besides, if the idea is as important an advance in scientific history as is said, we have but to wait a few years until Russia claims another "first," and then, of course, we'll have good reason to give it up.

The Great Gildersleeve, water commissioner of the air waves, will be presented with an A.W.W.A. membership certificate in the course of his broadcast Wednesday evening, March 23rd. Samuel B. Morris, A.W.W.A. Past-President and general manager of the Los Angeles department of water and power, will make the presentation, which will be heard over the NBC network. In addition, it is expected that the Gildersleeve adventures for that evening will be based on his water supply headaches.

(*Continued on page 4*)

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Postscripting our recent nosebeat (*see* January P&R p. 48), we can now report that Cornell University's smell-testing chamber has been dubbed the "Olfactorium," and is already being used in the conduct of basic research in "olfaction." Among other experiments being performed are some on odor blending, odor removal, odor masking and the thresholds of human odor perception, but our main immediate interest in the project stems from its promise soon to give us a uniform and practical technical vocabulary of smells. Apprised that many interested industries have already made generous contributions of odorous substances to Cornell's new "library of odors," the water works field eagerly awaits some evidence of reduction in its own receipts. But even failing that, we can look forward to a glossary of nostrilclature that is more definitive than our own "whiff of watermelon and stink of skunk."

Another means of getting around the unreliableness of the human snout is the procedure, based on rejection rather than refinement, recently developed by Dr. Lionel Farber of the G. W. Hooper Foundation, Univ. of California Medical School. Farber foregoes the dubious pleasure of sniffing in favor of measuring odor intensities chemically, using a test solution of potassium permanganate in alkali as his indicator. Developed originally to detect spoilage in fish, this test, which involves drawing a measured amount of chemically cleaned air through a definite volume of prepared odoriferous sample into the test solution, has already been applied to spices, coffee and bread. Who can tell where his next scent is coming from?

Hardly the "golden" jubilee, since it prides itself on being America's largest producer of cast-iron pressure pipe, the U.S. Pipe and Foundry Co. is nevertheless celebrating its 50th anniversary this month. Back in March, 1899, several producers with foundries located in eight states joined to form what was then called the U.S. Cast Iron Pipe and Foundry Co. In the course of its development, the company pioneered the American production of deLavaud centrifugally cast pipe in 1921, and now devotes more than 85 per cent of its output to the Super-deLavaud pipe developed in 1932. Pipe is now produced at four large and modernized plants at Bessemer and North Birmingham, Ala.; Chattanooga, Tenn.; and Burlington, N.J.; with other operations carried out elsewhere. At Burlington also is a large laboratory recently completed for research and development projects, with pilot plant facilities for static and centrifugally cast steel and iron products.

Engineering offices, laboratories and plant facilities of Walker Process Equipment, Inc., have been moved into a modern, one-story building at 518 Hankes Ave., Aurora, Ill. The former location was at 33 Hoyt Place, Aurora.

(*Continued on page 6*)

(*Continued from page 4*)

"The Story of Magnesium" is the first in a series of Techbooks published by the American Society for Metals to provide the nonengineering public with the technical information needed to understand the use of metals in industrial production. Within the educational range of the high school student or workman, the 260-page book has been written by W. H. Gross and can be used in a lecture series or plant course in conjunction with a film strip which is also available from the publishers. The book is cloth-bound and sells for $1.50 the copy from A.S.M., 7301 Euclid Ave., Cleveland 3, Ohio.

The position of superintendent of water works and sewerage in a southeastern city of 80,000 population is open for a young but well qualified and experienced engineer. The position is a new one which was created by the reorganization of the city's public works department, under the pressure of a $4,000,000 water supply construction project that has just begun. Beginning salary will be in the $5,000 to $6,000 range, depending upon the qualifications of the applicant. Address C. E. Perkins, City Manager, Winston-Salem, N.C.

(*Continued on page 8*)

(*Continued from page 6*)

Thar's gold in them thar taps, according to Mel Casson, cartoonist creator of the *Jeff Crockett* strip, which appears daily in the New York *Herald Tribune*. And to prove it, Casson has his cast of cartoon characters turn on their faucets to strike it rich. Explanation is that the gold, from a rich deposit, has been carried into the water system by underground rivers and streams. Result, apparently, is that the city water commissioner for once obtains cooperation in his conservation campaign.

Whimsical though the approach may be, any water works man will testify to the truth of Casson's basic principle. There is gold in "them thar taps," and they ought to be used accordingly. And though the gold isn't in the reapable, spendable form in which the Casson cast found it, that shouldn't reduce the public's appreciation of it.

We might, incidentally, point out that if the gold were more metallic than metaphoric, no inflation-struck water superintendent would let it escape his till, unless it were out California-way, where gold is by way of being more common than water these days.

One man who appears literally convinced that his water department has been filtering out a water-borne lode is H. D. Vaughn of El Paso, Tex., who recently sued the city for $54,114 to compensate for the injuries he sustained tripping over his backyard water meter. All of which seems to indicate that some people are too impatient even to wait until the gold reaches their faucets.

The continued distinction between professional and nonprofessional employees for collective bargaining purposes was urged upon the Senate Committee on Labor and Public Welfare by a panel sponsored by the Engineers Joint Council. The Senate committee is considering the revision of the Taft-Hartley Law, under which the distinction was introduced. Previously, according to the engineers, many engineers were prevented from bargaining separately from other employees even though their interests did not coincide and the professional group was unanimous in desiring the separation. The provisions of the Wagner Act forced them to be included in larger labor unions, in which they were often outvoted on specific issues by sheer numerical weight.

R. W. Murphey has been appointed advertising manager of the Taylor Forge & Pipe Works of Chicago.

W. R. Wischendorff has been appointed district manager of the western offices of Dearborn Chemical Co., with headquarters at 807 Mateo St., Los Angeles. For the past ten years he has been sales representative for Dearborn in central Wisconsin.

(*Continued on page 10*)

(*Continued from page 8*)

Shades of Dale Carnegie's past stole over the friendly facade of New York's Versailles Restaurant last January 21, as Jimmy Jemail, Inquiring Fotographer for the *Daily News,* elicited "the secret of their popularity with their friends" from a triumvirate of water works peddlers convivially contemplating their morrow's meeting with New York Section buddy-buds. At bat for the questioning cameraman were Casey Jones of Simplex Valve & Meter Co., Jake Van Atta and John Horgan of Ralph B. Carter Co.—and all three made hits, though not in that batting order, by bowling, by befriending friends and by felicitous forgetlessness.

At any rate, in the January 28 issue of the *News,* the fotogenic features of the above-named *wit*nesses, together with their "secret" testimony, appeared to take care of the male half of the personality poll. And we, of course, were gratified to note that our own water works personalities do carry so much apparent weight. As a matter of fact, taking our own experts at their word, we must confess that we spent last Saturday bowling, startled one of our friends by greeting him at a New York intersection and slapped a perfect stranger on the back to the tune of "Hello, Mike!" Quite confidentially, we have one fewer friends right now, and remain unpopular with the other, but we aren't giving up!

(*Continued on page 12*)


Teddy Roosevelt was president when we cleaned Washington's mains in 1907
1945 — National begins a 5 year job
Cleaning controlled by 2-way radio
NATIONAL CLEANING AGAIN
lowers pumping costs
increases volume
increases water pressure
FOR WASHINGTON, D. C.
Before cleaning
After cleaning

(*Continued from page 10*)

Damages due to water hammer were awarded in what may be a precedent-making decision in the Madison, Wis., federal district court last December. The action was based on the standard extended coverage clause in the insurance policy which the L. L. Olds Seed Co. of Madison had with the Commercial Union Assurance Co. of New York. After listening to expert testimony, the jury decided with the seed company that flood damage due to a broken main was caused by water hammer, and that water hammer was covered by the provisions of the policy as being actually an explosion within the pipe. The award for over $25,000 in water damages thus seems to have resulted from the decision that the sudden pressure waves which result when a flow of water is suddenly stopped, come within the definition of an explosion. As a result, it is believed likely that standard extended coverage clauses will be altered in the future to exclude damage due to water hammer, or that underwriters requirements will be revised to include water hammer arresting equipment.

W. H. Couse has been appointed eastern division manager of Smith-Blair, Inc., with headquarters in East Orange, N.J.

(*Continued on page 14*)

(*Continued from page 12*)

The Dry-Iceman Cometh, perhaps, back! Contradicting the official Air Force pronouncement of a couple of months ago (January P&R p. 4), two General Electric scientists and our old friend Dr. Irving P. Krick, president of the American Institute of Aerological Research, Pasadena, Calif., have revealed new successes in rainmaking, both with dry ice and with silver iodide vapor. In California, too, the editors of the Stanford University *Law Review* have indicated something less than faith in the Air Force conclusion by publishing a detailed discussion of the legal problems involved in "cloud-busting." And, finally, the U.S. Weather Bureau, which was party to the disillusioning Air Force experiments, has resumed investigations on its own. All of which suggest that the Air Force communique was, at the very least, a little premature.

As good as our word, however, we're eschewing this opportunity to do any detailed gloating and propose to postpone resumption of the regular monthly installments of the cloudburst chronicle until some further evidence, considered admissible even by the Air Force, is presented. Meanwhile, of course, we must admit that the success of the rainmakers will do a great deal to alleviate a drought of our own, in providing necessary raw material for both percolation and runoff.

But speaking of artificial inducement, yet another method of coaxing a water supply may soon be explored in Southern California. Observing that the Hemet-San Jacinto Valley earthquake of last December 4 not only doubled the flow from springs along the foothills, but rejuvenated other springs which hadn't flowed for years, geologists and engineers are wondering if they haven't discovered the real answer to the Southwest's water shortage. Admittedly it will take more than dry ice to provoke a productive temblor, but perhaps that problem would be more to the taste of the Air Force, which has had considerable experience in producing reasonable facsimiles thereof. At any rate, we shan't be too surprised to hear reverberations of the idea from our drought-ridden California confreres.

(*Continued on page 16*)

(*Continued from page 14*)

Competitive examinations for engineer officer appointments in the Regular Corps of the Public Health Service, in grades of junior assistant (2nd Lt.), assistant (1st Lt.) and senior assistant (Capt.) sanitary engineer, will be held April 11–13, 1949. Assignments in general sanitary engineering, water pollution control, environmental health research and other fields will be made with the individual's abilities and experience—as well as the opportunities for his career development—in mind. Entrance pay for the three grades, with dependents, is $3391, $3811 and $4489, respectively. Increases of 5 per cent in base pay for every three years of service, and promotions at regular intervals, are offered. Additional information and application forms are available from Surgeon General, Public Health Service, Washington 25, D.C., Attention: Div. of Commissioned Officers. Deadline for submission of applications is March 18, 1949.

Mathieson Chemical Corp. has contracted to purchase the business and assets of Southern Acid & Sulphur Co., Inc., through an arrangement which will distribute 265,000 shares of authorized but unissued common stock to the subsidiary's shareholders. The principal products of Southern Acid are sulfuric acid, phosphates, fertilizers, and sulfur.

(*Continued on page 18*)

(*Continued from page 16*)

Disposal of radioactive wastes occupied the attention of a number of leading members of the water supply and sanitary engineering profession during a seminar held by the Atomic Energy Commission at Washington, D.C., on January 24–25th. In his introductory remarks, AEC chairman David E. Lilienthal pointed out that we must "learn to live with radiation," and added that the problem could be solved as other problems have been solved—by learning as much as we can about it and by the application of the combined talents of the various scientific and engineering professions.

In the course of the session the sanitary engineering problems in the atomic energy industry were extensively discussed and appraised by members of the commission staff and seminar participants. The singular nature of the problem which sets it apart from most disposal operations is occasioned by the fact that there is no chemical or physical means by which the radioactivity which has been induced in a substance can be cancelled. For this reason it was compared by A.W.W.A. Vice-President A. P. Black to a clock which has been wound up to a certain point and which must be allowed to unwind at its own inexorable rate. Thus the problem can only be resolved by short-term retention of wastes that lose their radioactivity quickly, by concentration and long-term storage or exclusion to a safe place of wastes that remain active for long periods, or by dilution to safe limits.

Measurement and the setting of tolerance limits are essential tools in coping with such wastes, but the question of who sets the standards attracted considerable attention. As Abel Wolman, AEC consultant, observed: "This is one of the few industries . . . that is self-policing, and I doubt whether it ought to remain so." Outside health and sanitation agencies, many felt, would eventually have to concern themselves with the tolerance limits established, although there was praise for the earnest approach of the commission to the disposal problem. The radioactive level of the Clinch River, for example, into which the radioactive wastes from Oak Ridge are discharged, is considerably lower than that of many mineral waters used widely for drinking.

In addition to the A.W.W.A. members (the largest group attending), the organizations invited to participate included the Federation of Sewage Works Associations, the Conference of State Sanitary Engineers, the Conference of Municipal Sanitary Engineers, and various federal agencies.

The Leak Detector Co. has been formed, with D. L. Blaik as president and general manager, and has been appointed sole distributor for the "Universal" leak detectors and pipe locators produced by the Water Leak Detector Co. of Columbus, Ohio. The new company, which is affiliated with Cortrol, Inc. and other organizations specializing in corrosion control, submarine coatings, cathodic protection and electrolytic descaling, is located at 330 Bulkley Bldg., Cleveland 15, Ohio.

(*Continued on page 20*)

(*Continued from page 18*)

Jet propulsion, which descended upon us via the vagaries of aeronautics, wasted little time in adapting itself to such other media as pipe lighters, but even we had no idea it would so soon find its way into our medicine cabinets. Yet there it already is, in the form of a "brushless toothbrush," christened Orajet and characterized by a water-pressured squirt.

Developed by New York dentist Charles L. Hyser, the device consists of a 22-in. tube of transparent plastic with a detachable nozzle at one end and an expansion bolt at the other, weighing in at only 2 oz. Requiring only the assistance of some toothpaste, squeezed into the nozzle from an ordinary tube, and a normal tap pressure, the Orajet aimed accurately at the molars will do a much better job of cleaning than any brush and will avoid the possibility of abrasion cavities caused by scrubbing off enamel in an excess of enthusiasm. What's more, says Dr. Hyser, in addition to showing a "tremendous" reduction in mouth bacteria, the Orajet holds promise of preventing tartar formation.

A frustrated fireman since childhood, we're anxious to give the Hyser hose a try while we still have a few fangs left in our face. As a matter of fact, it's only the recent story of Rory, a lion in the Glasgow zoo, which gives us pause. Rory, it was, who mistook a garden hose in his cage for a snake, took a bite and ended up with a high-pressure jet in his throat which nearly drowned him. When resuscitated after 15 minutes of artificial respiration, Rory was observed to have a clean mouth, even though he forgot the toothpaste. But, tempering our zeal for cleanliness with a certain *joie de vivre,* we've not yet Orajetted.

L. L. Hedgepeth, formerly executive secretary of the Virginia State Water Control Board, has joined the American Cyanamid Co. as consulting engineer on industrial effluent problems. He will make his headquarters at the Bound Brook, N.J. plant of the company's Calco Chemical Division.

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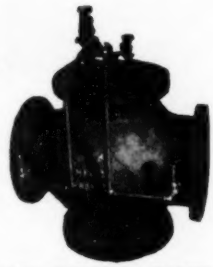
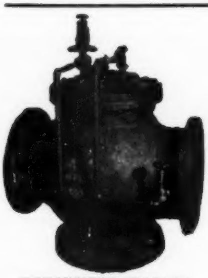


SURGE-RELIEF VALVE



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Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls

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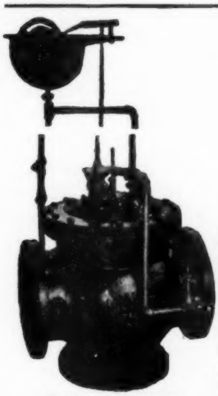

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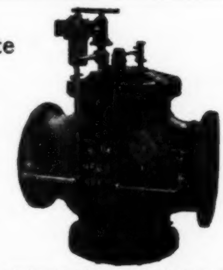

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Believe It

To the Editor:

We have never noticed a column like Ripley's "Believe It or Not" in the various publications of the A.W.W.A., but if you had one, we would be inclined to submit the name of a young lady now employed as a clerk in the Division of Water as being very apt in the water works field. This young lady's name, as it appears on our payroll, is Clorine Bugg.

G. W. Hamlin
Commissioner of Water and Heat
Dept. of Public Utilities
Cleveland, Ohio; January 24, 1949

We're afraid to give our readers the choice that Ripley does; we want them to believe that when the A.W.W.A. says so, it's so. Be that as it may, we wish to caution you to keep Miss Bugg out of the clutches of the Wallace & Tiernan Personnel Dept.—Ed.

Compliment and Supplement

To the Editor:

Congratulations! The new Journal cover and the addition of a cover picture is a great improvement over the cover of previous issues.

Also, again congratulations on your intentions to waive "water wenches, cover cuties and water maids" [January, P&R, p. 1] as cover photos. If I may, I should like to suggest that you use photographs of men or women (not to be confused with the so-called cover cuties) who are prominent figures in the water works profession, both past and present, or perhaps photographs of water purification plants and water works equipment (i.e., actual installations, without making advertising of them).

The Journal has been very useful to me in the past, and I am looking forward to each of the issues of the "better and more useful Journal."

John F. Kegebein Jr.
Chemist, Norristown Water Co.
Norristown, Pa.; January 25, 1949

To the Editor:

What the H—? Ain't we gonna get no more abstracts?

James T. MacKenzie
American Cast Iron Pipe Co.
Birmingham, Ala.; January 21, 1949

To Mr. Kegebein, thanks for the bouquets, and again thanks for the suggestions which will help us in our development of a cover policy.

To all those who intend to make suggestions, thanks for your early attention to that matter.

And to Dr. MacKenzie, Yup! But January was moving month, and though February found the abstracts at a new address and under a new name, you no doubt recognized them there. As a matter of fact, though "Condensation" will involve some reduction in articles abstracted, none of those from the hard-to-get foreign publications will be omitted. And such American articles as would have been covered will be included in reference only. All of which represents a slight pulling in of our horns dictated by the inflationary facts of publishing life. As for the relocation, although that too was effected for economy, it has made it possible for us to comply with the request of many of our members who wanted the abstracts printed in a location that would permit clipping.—Ed.

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Membership Changes

NEW MEMBERS

Applications received January 1 to 31, 1949

Allen, T. H., Water Supt., Madisonville, Tex. (Jan. '49)

Altman, Hollis S., Engr.-Mgr., J. B. McCrary Co., Inc., Box 126, S.L.I. Station, Lafayette, La. (Jan. '49)

Andrews, A. N., Supt., Water Works, Angleton, Tex. (Jan. '49)

Arnaud, Lee, Supt., Elec. Light & Water Dept., Jonesville, La. (Jan. '49)

Aulds, Talbert E., Supervisor, Utilities Field Work, Box 911, Sunray, Tex. (Jan. '49)

Badeaux, E. L., Water Supt., Box 871, Donna, Tex. (Jan. '49)

Baird, John E., Asst. Supt., Water Works, Florence Township, Florence, N.J. (Jan. '49)

Baldwin, Frank N., Director, Dept. of Utilities, City Hall, Houston, Tex. (Jan. '49)

Banks, Howard C., Supt., City Water Utility, 111 W. Pine Ave., Wildwood, N.J. (Jan. '49)

Barnhart, Kenneth, Dist. Engr., The Permutit Co., 523 BMA Bldg., Kansas City, Mo. (Jan. '49)

Barsumian, Nazareth, *see* Tower Lakes Water Co., Inc.

Barton, John V., Supt., City Water Works, Marlin, Tex. (Jan. '49)

Beadle, Raymond G., Water Supt., Spur, Tex. (Jan. '49)

Bishop, Marcus R., Chief Engr., Russell & Axon, Box 1431, Daytona Beach, Fla. (Jan. '49)

Blackmond, Randall, Water & Sewer Supt., 614 N. Water St., Monahans, Tex. (Jan. '49)

Blakeley, I. A., Supt. of Utilities, 510 W. Main St., Whitesboro 14, Tex. (Jan. '49)

Blucher, F. V., City Engr., Box 920, Corsicana, Tex. (Jan. '49)

Bolton, C. M., Mgr., Morgantown Water Co., 213 Fayette St., Morgantown, W.Va. (Jan. '49)

Boyd, Alvin, Water & Sewer Supt., Box 152, Pasadena, Tex. (Jan. '49)

Brand, Charles W., Pres., Biscayne Water Co., 502 First National Bank Bldg., Miami 32, Fla. (Jan. '49)

Brisco, G. N., Water Works Supt., Public Utilities Com., City Hall, Owen Sound, Ont. (Jan. '49)

Brodermann, Jorge, Civ. Engr., Calle K, No. 358, Vedado, Havana, Cuba (Jan. '49)

Brown, Eugene, Student of Chemistry, Univ. of Florida, Gainesville, Fla. (Jan. '49)

Cagle, Hollis, Supt., Utilities & Health Depts., City Hall, Childress, Tex. (Jan. '49)

Calmon, C., Head, Research Lab., The Permutit Co., Box 18, Birmingham, N.J. (Jan. '49)

Camejo, Daniel, San. Engr., 30 Rockefeller Plaza, New York 20, N.Y. (Jan. '49)

Carlock, Howard J., Chief Design Engr., American Water Works Co., 50 Broad St., New York 4, N.Y. (Jan. '49)

Carroll, J. A., Water & Sewer Supt., Box 904, Paducah, Tex. (Jan. '49)

Catron, Joe, Supt., Water Works, 1600 Ave. I, Rosenberg, Tex. (Jan. '49)

Chastain, A. O., Mgr., Munic. Water Works, Box 188, Wynne, Ark. (Jan. '49)

Clark, E. E., Supt., Water Dept., Humble, Tex. (Jan. '49)

Cogbill, Jess D., Chairman of the Board, Star City Water Co., Star City, Ark. (Jan. '49)

(*Continued on page 30*)

(*Continued from page 28*)

Concrete Conduit Co., M. C. Harford, Box 2670, Phoenix, Ariz. (Assoc. M. Jan. '49)

Cox, Emmett B., Water Supt., 611 E. Marvin Ave., Waxahachie, Tex. (Jan. '49)

Coyne, Glenn E., Water Works Supt., Box 189, Dilley, Tex. (Jan. '49)

Cushman, Robert L., Hydr. Engr., U.S. Geological Survey, Ground Water Branch, Box 2270, Tucson, Ariz. (Jan. '49)

Daniels, R. C., Supt., Water & Sewer Dept., Mexia, Tex. (Jan. '49)

Davis, Jack W., Dist. Mgr., Transite Pipe, Johns-Manville Sales Corp., 618 Continental Oil Bldg., Denver 2, Colo. (Jan. '49)

Dawson, H. D., Munic. Engr., Municipality of Saanich, Royal Oak, Vancouver Island, B.C. (Jan. '49)

Day, Everitt B., Supt., Public Works, 208 S. Esplanade St., Cuero, Tex. (Jan. '49)

Decker, Curtis D., City Mgr., City Hall, Grafton, W.Va. (Jan. '49)

deCordova, W. C., City Mgr., Box 867, Livingston, Tex. (Jan. '49)

Derr, Henry, Water Supt., 409 W. Kelly St., Pharr, Tex. (Jan. '49)

Dibdin, Frederick J. A., Asst. Engr., George P. Rice, Cons. Engr., 408 Audubon Bldg., New Orleans, La. (Jan. '49)

Dominguez, Alfredo E., Jr., Engr., Water Supply, Ministerio de Salubridad, Havana, Cuba (Jan. '49)

Douglas, Ralph W., City Engr., City Hall, Littlefield, Tex. (Jan. '49)

Drunagel, Franklin H., Plant Operator, City Water Dept., Port Arthur, Tex. (Jan. '49)

Dunn, L. N., Mgr., Munic. Water Works, Box 206, Camden, Ark. (Jan. '49)

Durham, Charles W., Cons. Engr., Henningson Eng. Co., 626 Standard Oil Bldg., Omaha, Neb. (Jan. '49)

Dutton, J. G., Water Supt., Knox City, Tex. (Jan. '49)

Dyer, Jack, Supt., Water Works, Box 901, Marfa, Tex. (Jan. '49)

Edwards, Marvin R., *see* White Star Chemical Corp.

Faneuf, G. Arthur, Supt., Water Works, City Hall, Concord, N.H. (Jan. '49)

Forehand, Albert S., Mgr., Water & Sewage Works, Earle, Ark. (Jan. '49)

Fuller, Jack F., Salesman, Hersey Mfg. Co., 426—30th Ave., S., Seattle 44, Wash. (Jan. '49)

Gilbert, Gordon M., Engr., Greater Vancouver Water Dist., Sun Bldg., Vancouver, B.C. (Jan. '49)

Glazener, Clifford, Water Supt., Box 353, Killeen, Tex. (Jan. '49)

Goforth, D. C., Water Supt., Box 31, Strawn, Tex. (Jan. '49)

Gonzalves, J. J. Autunes, Direccao des Servicos de Salubridade, Agente Tecnico de Engenharia, Pua Carlos Jose Barreiros, 14-2°E, Lisbon, Portugal (Jan. '49)

Grambling, P. G., Jr., Supt., Dept. of Water & Light, Ruston, La. (Jan. '49)

Grantham, Charles William, Water Works Supt., Box 6518, Baytown B, Tex. (Jan. '49)

Greenberg, Arnold E., Research Asst., Dept. of Civ. & San. Eng., Massachusetts Inst. of Technology, Cambridge 39, Mass. (Jr. M. Jan. '49)

Greene, W. E., Supt., Water & Light Dept., Box 111, Perry, Okla. (Jan. '49)

Griffin, Ralph G., Jr., Asst. Dist. San. Engr., Bureau of San. Eng., Box 1741, Fort Worth, Tex. (Jan. '49)

Gutsch, L. A., Supt., City Water Works, Washington, Ind. (Jan. '49)

Hall, James C., Mgr., Public Works Com., Fayetteville, N.C. (Jan. '49)

Hann, Victor, Director, Ozone Processes Div., The Welsbach Corp., 2409 W. Westmoreland St., Philadelphia 29, Pa. (Jan. '49)

Harford, M. C., *see* Concrete Conduit Co.

Harper, M. J., Vice-Pres., Pittsburgh Equitable Meter Div., Rockwell Mfg. Co., 50 Church St., New York 7, N.Y. (Jan. '49)

Haynes, William G., Water Supt., Box 1016, Kermit, Tex. (Jan. '49)

Heinsohn, Walter F., Water Supt., Odem, Tex. (Jan. '49)

Henley, Arvel, Supt., Water Dept., Box 225, Eufaulo, Okla. (Jan. '49)

Hester, Roy C., Water Supt., Water Production Dept., Box 1454, Big Springs, Tex. (Jan. '49)

(*Continued on page 32*)

(*Continued from page 30*)

Hines, G. H., Water Supt., Box 508, Tahoka, Tex. (Jan. '49)

Hoagland, William E., Jr., Water Service Man, Jericho Water Dist., East Norwich, N.Y. (Jan. '49)

Hunter, Hugh H., Chief Engr., Public Service Com., 1742 Munsey Bldg., Baltimore 2, Md. (Jan. '49)

Jenkins, Frank M., Supt., Public Works, Water Works, 123 Holley St., Brockport, N.Y. (Jan. '49)

Johnson, George P., Owner-Mgr., Soft Water Service, 118 W. Santa Fe Ave., Fullerton, Calif. (Jan. '49)

Joyce, F. J., Jr., Water Supt., Mt. Vernon, Tex. (Jan. '49)

Kapp, Clyde W., Mgr., Blytheville Water Co., Box 308, Blytheville, Ark. (Jan. '49)

Kelley, W. C., Supt., Water & Sewers, Box K, Bogata, Tex. (Jan. '49)

Kelly, John H., Civ. Engr., New York City Dept. of Water Supply, Gas & Elec., Box 232, Katonah, N.Y. (Affil. Jan. '49)

King, David E., Post Engr., Camp Hood, 1010 S. 4th St., Temple, Tex. (Jan. '49)

King, Loyd H., Mgr., Florida Utilities Corp., 1052 Kentucky Ave., Winter Park, Fla. (Jan. '49)

Kingsley, John F., Chemist-in-Charge, Filter Plant, R.D. 2, Newburgh, N.Y. (Jan. '49)

Krum, W. E., Mgr.-Owner, Shastina Water Co., Weed, Calif. (Jan. '49)

Lamb, W. G., Supt., Water Dept., Box 282, Greenwood, Ark. (Jan. '49)

Lambert, J. E., *see* Teague, City of

Lamm, Walter E., Partner, George West Utilities, George West, Tex. (Jan. '49)

Leonard, Frank H., Dist. Repr., The Permutit Co., 3903 Olive St., St. Louis 8, Mo. (Jan. '49)

LeRiche, Arthur, Water Works Supt., Filter Plant, St. Andre St., Acton-Vale, Que. (Jan. '49)

Letbetter, W. M., Supt., Water & Sewer Improvement Dist., 122 W. 2nd, Corning, Ark. (Jan. '49)

Lewis, L. L., Vice-Pres., Carrier Corp., 300 S. Geddes St., Syracuse 1, N.Y. (Jan. '49)

Lockport Com. of Public Works, Levell Moon, City Bldg., Lockport, N.Y. (Mun. Sv. Sub. Jan. '49)

Lovrien, N. R., Sales Repr., Chicago Pump Co., 614 Standard Oil Bldg., Omaha, Neb. (Jan. '49)

Lowrie, J. D., Supt., Water & Sewers, Munic. Water Supply, Marvell, Ark. (Jan. '49)

Mack, Sid S., Sid Mack Co., 2222 W. Beaver St., Jacksonville, Fla. (Jan. '49)

Mahan, Wesley E., Mgr., Morrilton Water Co., Box 296, Morrilton, Ark. (Jan. '49)

Markov, T. S., Chief Chemist, Fibreboard Products, Inc., Box CC, Antioch, Calif. (Jan. '49)

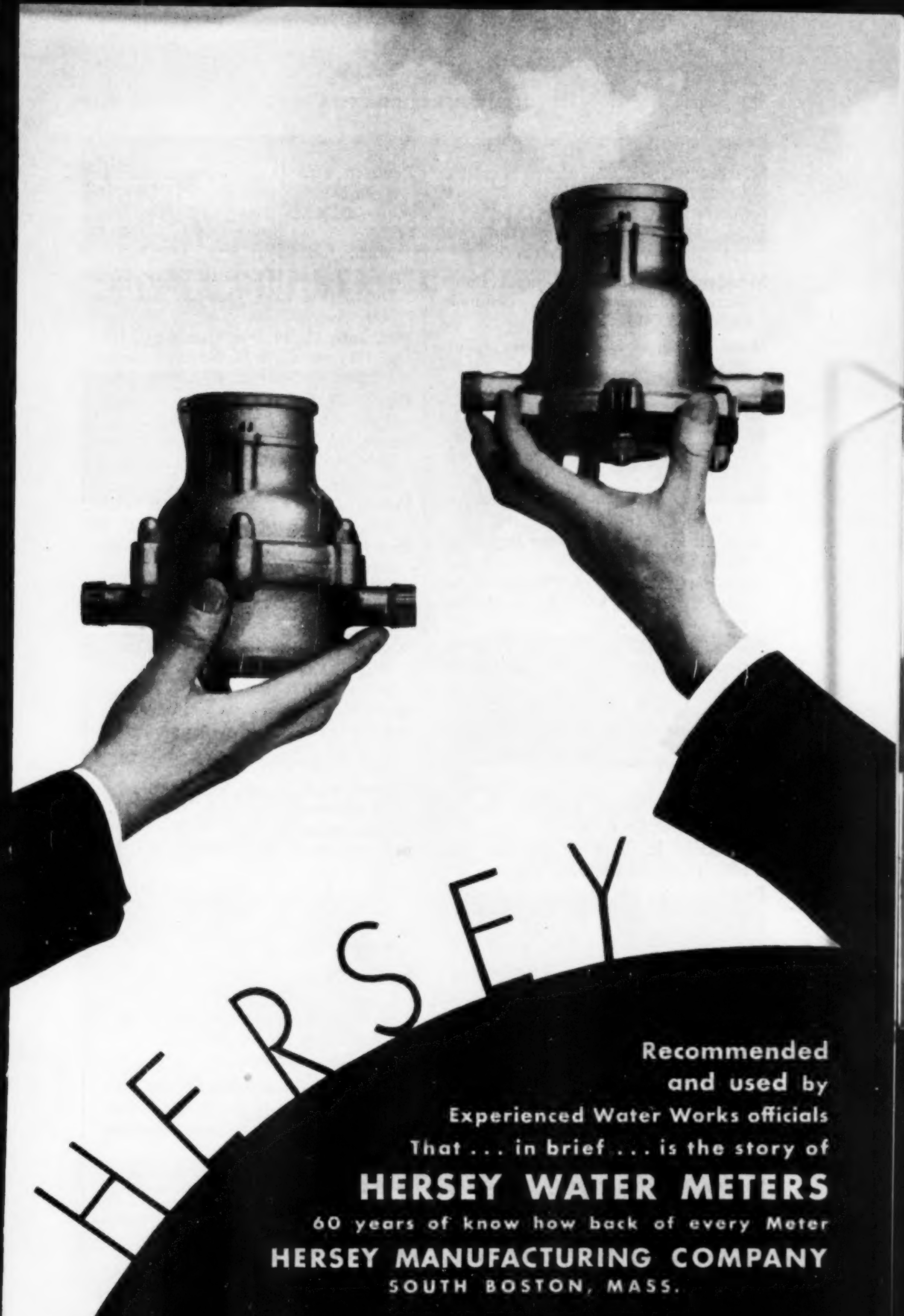
Mau, Francis, San. Engr., Suburban Water System, 706 Kamuela Ave., Honolulu 41, Hawaii (Jr. M. Jan. '49)

McCarver, R. M., City Mgr., Sonora, Tex. (Jan. '49)

McConnell, Otis, Supt., Water & Sewers, Cotton Plant, Ark. (Jan. '49)

McPherson, T. R., Supt., Water Dept., Box 241, Alpine, Tex. (Jan. '49)

(*Continued on page 34*)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Merron, Morton, Asst. Engr., Russell & Axon, 201 N. Wildolive Ave., Daytona Beach, Fla. (Jan. '49)

Meyer, A. E., Supt., Water & Sewers, Box 150, Jefferson, Tex. (Jan. '49)

Montgomery, Homer M., Supt., Public Works, Municipal Bldg., Seminole, Okla. (Jan. '49)

Moon, Levell, *see* Lockport Com. of Public Works

Morgan, Robert M., Director of Water, City Bldg., Fairmont, W.Va. (Jan. '49)

Morlan, Loren W., Chief Clerk, City Water Dept., 1310 Jackson Ave., Lakewood 7, Ohio (Jan. '49)

Murphy, E. I., Mgr., Water Works, DeValls Bluff, Ark. (Jan. '49)

Napp, R. P., Water & Sewer Supt., DeKalb, Tex. (Jan. '49)

Neffendorf, Alfred, Supt., Water Works, Munic. System, Box 147, Fredericksburg, Tex. (Jan. '49)

Nelson, Carl E., Gen. Water Inspector, Great Northern Ry. Co., Grand Forks, N.D. (Jan. '49)

Nesbitt, John B., Student of San. Eng., Massachusetts Inst. of Technology Graduate House, Cambridge 39, Mass. (Jr. M. Jan. '49)

Nettum, W. C., Filter Plant Operator, City Water Dept., 735—3rd St., N., Fargo, N.D. (Jan. '49)

Orr, Harry L., Supt. of Utilities, City Hall, Kewanee, Ill. (Jan. '49)

Peebles, J. A., Asst. Engr., Canadian National Rys. & Water Service Board, 460 Union Depot, Winnipeg, Man. (Jan. '49)

Peterson, Erik D., City Engr., 315—6th Ave., N.E., Jamestown, N.D. (Jan. '49)

Pettengill, C. L., Pres., Filter-Soft Corp., 16301 Grand River Ave., Detroit 27, Mich. (Jan. '49)

Pheny, Judson C., Engr., City Water Dept., Box 1066, Decatur, Ala. (Jan. '49)

Pita, Julio C., Prof. of Chemistry, Univ. of Havana, Calle B, No. 351, Vedado, Havana, Cuba (Jan. '49)

Pope, Albert J., Mgr. of Utilities, Box 952, Coleman, Tex. (Jan. '49)

Porter, Earl, Civ. Engr., Porter, Barry & Switzer, 211 Main St., Baton Rouge, La. (Jan. '49)

Porter, John F., Supt., Water Dept., City Hall, Grants Pass, Ore. (Jan. '49)

Raney, Leslie A., Supt., Water Works, Box 86, Silsbee, Tex. (Jan. '49)

Reaves, Samuel Howard, Supt., Water & Sewage, City Hall, Winchester, Va. (Jan. '49)

Richards, T. G., Supt., Whittier Extension, Mutual Water Co., 857 Walnut Ave., Puente, Calif. (Jan. '49)

Ruck, Franklin, *see* Troy Water Dept.

Schindler, Richard R., Instructor, College of Eng., Univ. of Santa Clara, Santa Clara, Calif. (Jan. '49)

Seabolt, M. L., Supt., Water Works, Box 93, Mulberry, Ark. (Jan. '49)

Sellers, Malcolm, Supt., Munic. Light & Water Plant, Madisonville, Ky. (Jan. '49)

Short, U. L., Water Supt., Box 208, Premont, Tex. (Jan. '49)

Smith, Doyle, Water Supt., Box 3, Hobart, Okla. (Jan. '49)

(*Continued on page 36*)

(*Continued from page 34*)

Smith, Marlo E., Capt., Army Medical Center, Fort Totten, N.Y. (Jan. '49)

Smith, Walter Hall, Water Supt., California-Oregon Power Co., Winchester, Ore. (Jan. '49)

Snelson, Grover, Water Supt., 916 W. 2nd, Chetocah, Okla. (Jan. '49)

Springer, A. L., Supt., Water & Sewage, Box 211, Big Lake, Tex. (Jan. '49)

Stearns, H. F., Dist. Sales Mgr., Chicago Bridge & Iron Co., 57 Forsyth St., N.W., Atlanta 3, Ga. (Jan. '49)

Steininger, H. M., Chief Chemist, Research Dept., Standard Oil Co. of Indiana, Sugar Creek, Mo. (Jan. '49)

Storms, J. R., Salesman, Johns-Manville Sales Corp., 26 Dean St., Westwood, N.J. (Jan. '49)

Sutterfield, J. A., Water Works Supt., Heber Springs, Ark. (Jan. '49)

Teague, City of, J. E. Lambert, City Secy.-Mgr., 521 Main St., Teague, Tex. (Corp. M. Jan. '49)

Tompkins, Arthur G., Supervisor, Water Test Dept., Baltimore & Ohio R.R. Co., Pratt St. & Arlington Ave., Baltimore 23, Md. (Jan. '49)

Tower Lakes Water Co., Inc., Nazareth Barsumian, Mgr., Tower Lakes, Barrington, Ill. (Corp. M. Jan. '49)

Troy Water Dept., Franklin Ruck, 1316 E. Main St., Troy, Ohio (Corp. M. Jan. '49)

Turner, Samuel F., Dist. Engr., U.S. Geological Survey, Ground Water Branch, Box 2270, Tucson, Ariz. (Jan. '49)

Vaughan, Curt, Water Supt., City Hall, Rogers, Ark. (Jan. '49)

Vernon, O. D., Water Supt., Box 12, Morton, Tex. (Jan. '49)

Walker, Amos, Supt., City Water Works, Marion, Ark. (Jan. '49)

Walker, I. H., Water Supt., Box 625, Jasper, Tex. (Jan. '49)

Walkinshaw, William M., 23 Valhalla Blvd., Toronto 13, Ont. (Jan. '49)

(*Continued on page 38*)

(*Continued from page 36*)

Walling, I. W., U.S. Geological Survey, Chemist in Charge, Oklahoma A & M College, 306 Chemistry Bldg., Stillwater, Okla. (Jan. '49)

Warner, R. B., Mgr., City Water Works, City Hall, Walnut Ridge, Ark. (Jan. '49)

Weishaupt, H. M., Asst. Comptroller, Hershey Estates, 9 W. Chocolate Ave., Hershey, Pa. (Jan. '49)

White, Hardin, Supt., Water & Sewage, Altus, Okla. (Jan. '49)

White Star Chemical Corp., Marvin R. Edwards, Gen. Mgr., Box 4615, Jacksonville, Fla. (Corp. M. Jan. '49)

Whitten, Brewer N., Water Plant Operator, Fieldcrest Mills, Fieldale, Va. (Jan. '49)

Williams, C. A., Mgr., Munic. Water System, 317 York St., Helena, Ark. (Jan. '49)

REINSTATEMENTS

Ayers, Edward D., Service Engr., Pittsburgh Equitable Meter Div., 64 Susquehanna Ave., Cooperstown, N.Y. (Apr. '47)

Bushell, A. L., *see* Norwich Public Utilities Com.

Crossman, A. B., Sales Supervisor, Rockwell Mfg. Co., Box 2126, Houston 1, Tex. (Oct. '39)

Ebsary, W. F., Chief Chemist, City Water Dept., Tampa, Fla. (Jan. '47)

Elder, George Randolph, Sr., Supt., Dept. of Public Utilities, 200—3rd St., Radford, Va. (July '43)

Evans, Samuel A., Civ. Engr., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Jan. '34)

Fortin, Joseph O., Supt., Water & Sewers, Glen Ellyn, Ill. (July '42)

Gahr, William N., San. Engr., State Health Dept., Bismarck, N.D. (Jan. '46)

Gibson, S. C., *see* Silver City Water Dept.

Harbert, Virgil R., Operator, Lumberport Water Co., Lumberport, W.Va. (Affil. Jan. '44)

Hutchinson, Dale, Water Comr., 45 S. Lake St., North East, Pa. (Jan. '40)

Lanctot, Theo., Cons. Engr., Ste. Marie & Lanctot, 63 Main St., Hull, Que. (Mar. '26)

Levy, A. Zabdiel, 4215 Liberty Heights Ave., Baltimore 7, Md. (Jan. '40)

Mason, Ernest R., Mason Heating & Soft Water Service, 343 Talbot St., London, Ont. (July '43)

Merrill, Neal P., Mio, Mich. (Apr. '43)

Millspaugh, D. V., Water Supt., 712 S. 7th St., Clinton, Okla. (Oct. '46)

Montpelier, City of, Water Dept., City Hall, Montpelier, Vt. (Corp. M. Jan. '43)

Nelson, William R., Asst. Power House Supt., Reynolds Metals Co., Hurricane Creek Plant, Bauxite, Ark. (Oct. '46)

Norwich Public Utilities Com., A. L. Bushell, Secy.-Treas., Norwich, Ont. (Corp. M. Oct. '44)

Pierron, L. L., City Chemist, Water & Sewage, City Bldg., Greenville, Ohio (Oct. '47)

Sanders, Verne G., Civ. Eng. Assoc., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '47)

Silver City Water Dept., S. C. Gibson, Supt., Box 597, Silver City, N.M. (Corp. M. Oct. '41)

Thomas, Evan, Supt., Fairport Water Dept., Village Hall, Fairport Harbor, Ohio (Oct. '47)

Thomas, George E., Clerk, Board of Public Affairs, 9—2nd St., Willoughby, Ohio (July '47)

Thomas, M. C., Supt., Water Works Plant, Cheraw, S.C. (Jan. '47)

Winters, Daniel L., Chemist, Gulf Public Service Co., Inc., New Iberia, La. (Oct. '45)

LOSSES

Deaths

Banta, A. Perry, Assoc. Prof. of San. Eng., California Inst. of Tech., Pasadena 4, Calif. (Oct. '38) *PR*

Brown, Herbert H., Supt. of Water Works, City Hall, Milwaukee 2, Wis. (Nov. '29) *Director '40–'43. Fuller Award '44.*

Campbell, Joseph D., Supt., Merchantville-Pennsauken Water Com., 13 W. Maple Ave., Merchantville, N.J. (Oct. '38) *MP*

(*Continued on page 40*)

(*Continued from page 38*)

Herr, Harry N., Chief Civ. Engr., Hershey Estates, 213 W. Chocolate Ave., Hershey, Pa. (Oct. '44) *MPR*

Lovejoy, Walter L., City Engr., 611—3rd St., Hoquiam, Wash. (Jan. '36) *MP*

Moon, Philip G. G., Resident Director, Bournemouth Gas & Water Co., 136 Old Christchurch Rd., Bournemouth, England (Oct. '32)

Vail, H. P., Sr. Engr., Operation & Maint. Div., Metropolitan Water Dist., 306 W. 3rd St., Los Angeles 13, Calif. (Oct. '39) *MP*

Waddell, W. H., City Engr. & Supt., Water Dept., City Hall, Owen Sound, Ont. (July '35) *MR*

Resignations

Aaron, W. F., Grand Rapids, Mich.

Akers, Arthur K., New York, N.Y.

Albright, Walter B., Newcomerstown, Ohio

Archbell, Clarence, Marshall, Tex.

Basom, G. E., Fairmont, Minn.

Bolieau, Clifton W., Knoxville, Tenn.

Cadman, Robert M., Red Bank, N.J.

Casad, Orla, Merced, Calif.

Chase, H. Percival, Los Angeles, Calif.

Consolidated Western Steel Corp. [**Los Angeles**], Los Angeles, Calif.

Dalton, Donald H., Washington, D.C.

Darco Corp., New York, N.Y.

Darling, Ernest Howard, Hamilton, Ont.

Davis, Marvin L., Akron, Ohio

Dixie Lime Products Co., Ocala, Fla.

Dumont, Romuald, Coaticook, Que.

Duy, Carl, Aurora, Ill.

Epstein, Frank, Los Angeles, Calif.

Fuller, Harry U., Portland, Me.

Gordon, Milton Oliver, Ft. Lauderdale, Fla.

Grant, S. L., Winchester, Va.

Hallam, James P., Lostock, Near Bolton, Lancaster, England

Hamig, Louis L., St. Louis, Mo.

Henson, Frederick J., Washington, D.C.

(*Continued on page 42*)

(*Continued from page 40*)

Hoskins, J. K., Chevy Chase, Md.
Kellogg, James Wilford, Raleigh, N.C.
Kent, Frederick S., Ann Arbor, Mich.
King Elizabeth (Miss), Memphis, Tenn.
Kruger, Albert L., DeLeon Springs, Fla.
Landgraf, George F., Royal Oak, Mich.
Lapp Insulator Co., Inc., LeRoy, N.Y.
Latta & Fent, Salina, Kan.
Lill, John R., Baltimore, Md.
Martin, William A., Summit, N.J.
McCord, Bertram, River Rouge, Mich.
Meissner, William A., Jr., Garfield Heights, Ohio
Mortenson, Everett N., Hammond, Ind.
Myers, Bert E., Rhinebeck, N.Y.
Nuebling, Edward, New York, N.Y.
Olson, Willard Martin, Chicago, Ill.
Rider, Bert A., Phillips, Tex.
St. John, C. H., Pensacola, Fla.
Shaver, Arthur, New York, N.Y.
Shedden, John S., East Orange, N.J.
Sichler, Vance A., Seattle, Wash.
Skinner, Hervey J., Boston, Mass.
Stokvis, R. S., & Sons, Inc., New York
Tillman, D. L., Cheraw, S.C.
Van Pelt, Richard, Salem, Ore.
Weagraff, Charles R., Salamanca, N.Y.
Weed, Sam A., Oakland, Calif.
Weir, Kenneth J., Chicago, Ill.
Welsh, J. V., Los Angeles, Calif.
Wilson, H. K., St. Petersburg, Fla.
Young, T. L., Chester, W.Va.

CHANGES IN ADDRESS

Changes received between January 5 and February 5, 1949

Binyon, Hugh A., Hydro Service Co., 6235—6th Ave., N., St. Petersburg 5, Fla. (Oct. '47) *P*

Carpenter, R. B., Jr., Box 310, Thomasville, N.C. (Jan. '48)

Coughlin, L. J., 3170 State St., San Bernardino, Calif. (Oct. '38) *MP*

Davis, Don C., Munic. Engr., Quinton Engrs., Ltd., 815 S. Figueroa St., Los Angeles 14, Calif. (Jan. '41) *M*

Easterwood, Elmer G., Asst. Supt., Water Dept., 414 E. Indiana St., Maumee, Ohio (Jan. '46)

(*Continued on page 44*)

(Continued from page 42)

Freeman, E. M., Cons. Civ. Engr., E. M. Freeman & Assoc., Texas Eastern Bldg., Shreveport 23, La. (July '46)

Fuller, Harry Lawrence, Sales Engr., Brik-Re-Nu Co., 420 E. 73rd Terrace, Kansas City 5, Mo. (July '42) *P*

Holland, Paul L., Director of Public Works, 300 Municipal Bldg., Baltimore 2, Md. (Mar. '32) *M*

Irwin, William F., 1256 Delta Ave., Cincinnati 8, Ohio (Oct. '38)

Kachelhoffer, Fred G., 6218 N. Oberlin, Portland 3, Ore. (July '45) *P*

Kenny, Norbert J., Rockwell Mfg. Co., 645 Munsey Bldg., Washington, D.C. (Apr. '38)

Kleinbach, Howard W., Structural Eng. Asst., Dept. of Water & Power, 207 S. Broadway, Los Angeles, Calif. (July '47)

Koopman, George, Township Engr., Wyoming Township, 1155—28th St., S.W., Grand Rapids, Mich. (July '46) *MR*

Lawson, Hugh C., Rensselaer Valve Co., 417 S. Hill St., Los Angeles 13, Calif. (Apr. '37)

Martin, H. Fred, Vice-Pres., Garrett Eng. Co., Cons. Engrs., 5008 Alameda Rd., Houston, Tex. (Jan. '46) *MPR*

McCarthy, Gerald T., Knappen Tippetts Abbett Eng. Co., 62 W. 47th St., New York 19, N.Y. (Apr. '42) *PR*

McGauhey, P. H., 3940 Welland Ave., Los Angeles 43, Calif. (July '38) *P*

McRae, J. P., McRae Eng. Equipment, Ltd., 147 University Ave., Toronto 1, Ont. (Jan. '24) *P*

Morris, T., Mgr., Dauphin Cons. Water Supply Co., Broad St. Station, Philadelphia 2, Pa. (Jan. '41)

Pearl, Emanuel H., Public Health Engr., County Health Dept., 3036 Paseo del Refugio, Santa Barbara, Calif. (Jan. '37) *MPR*

Pennsylvania Salt Mfg. Co., George B. Beitzel, 1000 Widener Bldg., Philadelphia 7, Pa. (Assoc. M. June '03)

Seufer, Paul E., Lt. Comdr., 526 Moreell Blvd., Orange, Tex. (Apr. '37)

Slattery, Patrick J., 80 Cherbourg St., Sherbrooke, Que. (July '48)

Smith, David Barry, Dept. of Civ. Eng., Univ. of Florida, Gainesville, Fla. (Jan. '46) *M*

Snow, Donald L., San. Engr., U.S. Public Health Service, National Inst. of Health, Rockville Pike, Bethesda, Md. (Jan. '46) *MPR*

Snyder, Leonard L., Backflow Eng. & Equipment Co., 5725 Alcoa, Los Angeles 11, Calif. (Apr. '44)

Soder, Darwin R., Dist. Mgr., Layne-Western Co., 1011 Wheeler, Wichita 12, Kan. (Apr. '46)

Spaeder, Harold J., c/o The Dorr Co., 800 Peachtree St., N.E., Atlanta, Ga. (Oct. '46) *P*

Spaulding, Charles H., 708 S. Overlook Drive, Alexandria, Va. (July '24) *Goodell Prize '33. Fuller Award '40.*

Stutts, K. V., Supt., McLennan County Water Control & Improvement Dist. No. 1, 1027 Kane Ave., Waco, Tex. (Apr. '43) *P*

Turner, Harold A., Service Engr., Ohio Salt Co., 118 E. North St., Waynesboro, Pa. (July '48)

Wild, Harry E., Cons. Engr., 421 Wisteria Rd., Daytona Beach, Fla. (July '46) *PR*


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AFRICAN SUPPLIES

The Great Dams in Algeria. L. Descroix. L'Eau (Fr.), **35**:126 (Aug. '48). Describes enormous difficulties of dam construction in bad terrain, soil movement, lack of resistance of porous and friable rock. The Oued Fodda Dam, 100 m. high and 68 m. long, requiring 300,000 cu.m. of concrete, created storage reservoir of 225,000,000 cu.m.; old Hamiz Dam, 7 m. high and 45 m. long, with reservoir capacity of 23,000,000 cu.m., provides irrigation for about 140,000 acres; Ghrib rigid type of dam, 65 m. high, constructed in broken territory with great ingenuity; Bakhadda Dam, requiring footings 17 m. below surface for height of 45 m., provides storage of 37,000,000 cu.m.; Bou-Hanifa core dam, 460 m. long with height varying from 4 to 125 m., has filter located at foot. Filter consists of 5 beds with successively larger filter material, varying from dune sand for first filter to stone 25–60 mm. in diam. in upper filters; Beni-Bahdel reinforced concrete dam is newest; 47 m. high, it provides storage for 63,000,000 cu.m. There are also some smaller dams. Several new dams projected to provide irrigation for Mina, plain of Chéliff, basin of Hamiz and virgin, fertile soils of south.—*W. Rudolfs.*

Water Filtration at Relizane [Algeria]. J. Hallopean. L'Eau (Fr.), **35**:141 (Aug. '48). Water from Mina Wadi, regulated by Bakhadda Dam, is pumped in canal basin which constitutes head of irrigation zone. Filter plant, located at foot of basin canal, treats about 6,000 cu.m. per day. Water varies greatly from 80 to 1,500 ppm. suspended solids, pH 7.4 to 8.4, sulfates (SO_3) 250 to 1000 ppm., Cl 400 to 480 and CaO alkalinity 90 to 165 ppm. Plant consists of coagulation and settling basins, 6 rapid sand filters and sterilization apparatus.—*W. Rudolfs.*

Potable Water Supply in Egypt. Anon. L'Eau (Fr.), **35**:181 (Nov. '48). Cholera epidemic during '47 focused attention on need for potable water supply control. Egypt has 19,000,000 inhabitants, increasing rapidly, with pop. density of 900 per sq.mi. About 75% of pop. rural; mortality 26.7%, birth rate 430 and infant mortality 152 per 1000 inhabitants. Water taken directly from Nile or its canals. In 35 towns with more than 30,000 people each (6,000,000 total), distr. systems exist. At Cairo, water treated by settling, coagulation and chlorination. Alexandria takes water from heavily pold. Mahmoudieh Canal, contg. 500–800 ppm. suspended solids and 10,000 coliform organisms per ml.; water treated by coagulation and settling, rapid sand filters and chlorination. Water taken from Suez Canal by number of cities is treated similarly. In provincial cities water treatment and distr. in poor state. Whereas in cities with good water control cholera cases are few, provincial towns such as Mansourah (pop. 138,000, water consumption 13 gal./cap.) and Zazazig

(*Continued on page 50*)

(*Continued from page 48*)

(pop. 133,300, water consumption 7.5 gal./cap.), using chemically treated and filtered water, had 2889 and 2069 cholera cases, resp. Cairo, with 1,799,000, and Alexandria with 750,000 people had 23 and 71 cases, resp. Plans being made to ameliorate conditions in rural areas and it is expected that by '57 potable water will be supplied to 8,000,000 people.—*W. Rudolfs.*

Alexandria [Egypt] Water Supply. Anon. Wtr. & Wtr. Eng. (Br.), **51**: 285 (June '48). Annual report for '47 states that vol. of water supplied exceeded that for '46 by 1,354,000 cu.m. Cholera epidemic during '47 made adoption of emergency measures necessary. Supply of unfiltered garden water suspended, treatment of water and sterilization intensified, large numbers of public taps installed in poorer quarters, and mains laid to supply many of outlying districts. Increase of 3,618 in number of private consumers. At Siouf works, clarifier of 35,000 cu.m. per day capacity completed and filtration plant enlarged to give additional daily output of 12,500 cu.m. At Rond-Point works, new filter house capable of delivering 14,000 cu.m. per day completed in July. Distr. system extended by 7.7 km. at total cost of £35,161.—*H. E. Babbitt.*

South African Water Supply Notes. Anon. Wtr. & Wtr. Eng. (Br.), **51**: 484 (Oct. '48). During first year of existence of East Africa groundnut scheme, 20 boreholes drilled with little success. Geophysical survey parties now finding water in Southern Rhodesia and East Africa. They have already selected nearly 1000 borehole sites. Last year they put down boreholes in Southern Rhodesia which produce thousands of gal. of water per hr. On advice of cons. engr. and cons. geologist, original design for

(*Continued on page 52*)

(Continued from page 50)

Durban's Umgeni Dam has been considerably amended. Earth dam on left flank has been replaced by concrete gravity section. Progress has been considerably delayed by foundation troubles, difficulty of procuring heavy equip., and delay in provision of adequate power supply. Latest irrigation scheme for northern Kalahari proposes to use swamp areas of Okovanago Delta and divert surplus flow into Botletle R., which might bring 2,000,000 acres under drainage in western zone of delta.—*H. E. Babbitt.*

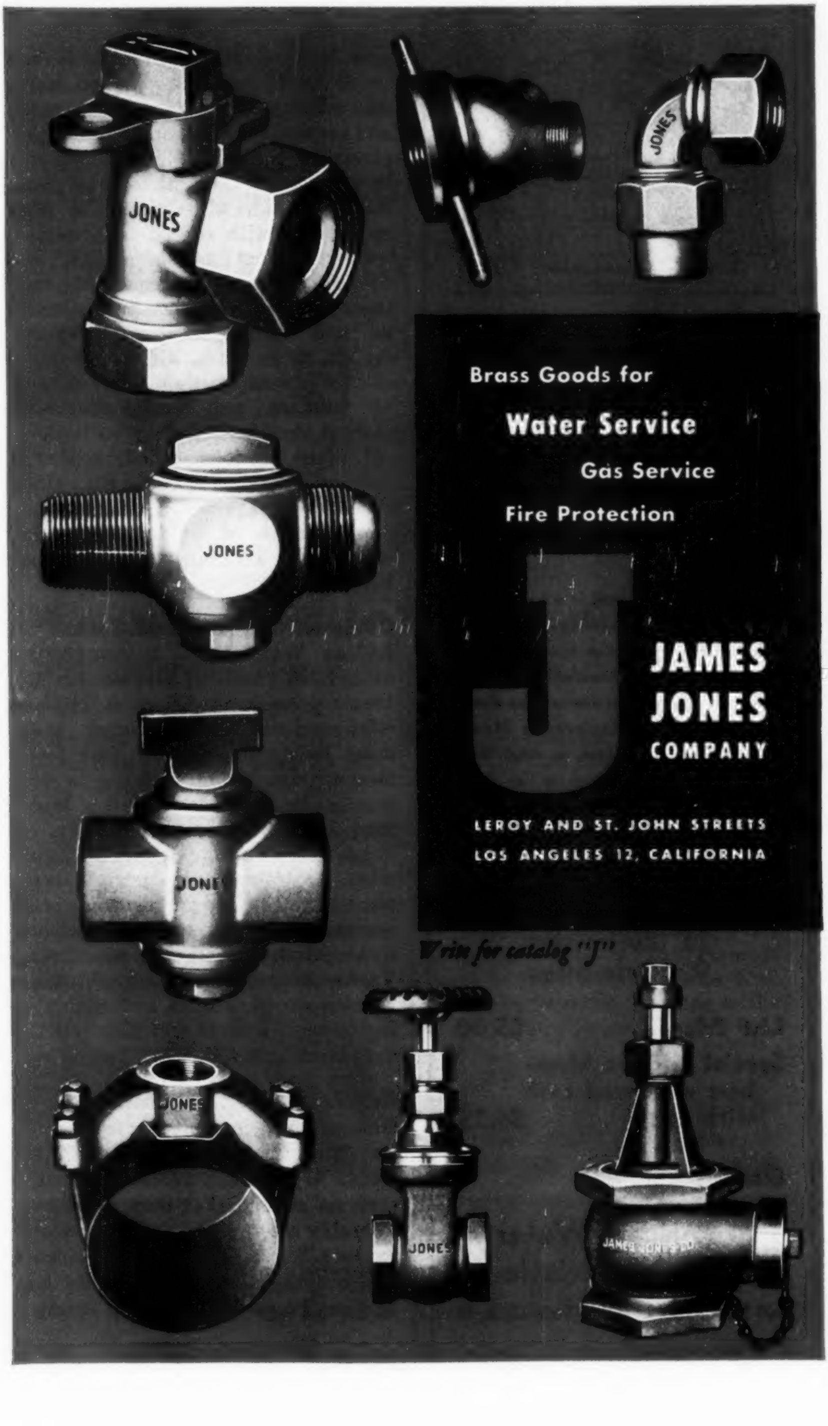
Durban's [Un. S. Afr.] Water Scheme Progressing. ANON. Wtr. & Wtr. Eng. (Br.), **51**:286 (June '48). By end of '48, 20 mil.gal. (Imp.) from Lower Table Mt. water scheme will assure adequate supply of water for Durban's domestic, industrial and shipping requirements. Main dam will be completed about June '49.—*H. E. Babbitt.*

Makeup Water Pumping for Klip [Un. S. Afr.] Power Station. H. W. HUTTON. Wtr. & Wtr. Eng. (Gt. Br.), **51**:518 (Nov. '48). Total crude water makeup requirements avg. 263 mil.gal. (Imp.) per month. Water drawn from Vaal R. by pumping station situated on river, and delivered into cooling tower ponds at Klip through two 18″-diam. spun-concrete-lined pipelines 26,621′ and 28,536′ long, resp. Design considerations included: [1] river fluctuations of as much as 28′; [2] fact that when river in flood, considerable quants. of debris brought down at density sufficient to choke up any normal type of pump strainer; and [3] necessity for absolutely reliable water supply. Main pumping equip. comprises 3 motor-driven centrifugal 2-stage horizontal pumps (2 running and 1 standby), each for normal output of 3,000 gpm. (Imp.) when pumping against total head of 264′. Non-overloading characteristics selected so that power between initial and final conditions does not change more than 0.3%. Backflushing facilities included to permit reverse flow of water to wash off debris collected around outside periphery of suction strainer. Since foot valves could not be used, necessary to install vacuum priming system. Two motor-driven air-exhauster pumps of sliding-vane type provided to prime pump chambers and suction piping. Means of preventing normal closing action of delivery check valves consists essentially of lifting lever keyed to operating spindle situated below, and parallel with, reflux valve spindle. Pipelines of mild steel plate, $\frac{3}{16}$″ thick, lined with $\frac{1}{2}$″ spun concrete giving finished internal diam. of 18″. Each pipeline provided with 3 reflux, 3 sluice and 2 scour valves, and 4 automatic air-release valves. First test on pipeline No. 1 showed head loss of 110′ corrected to flow of 3,000 gpm. (Imp.). First test on No. 2 pipeline gave 90′ loss. Within 6 mo. after test, friction head on No. 1 line rose to 151′ and thereafter, for 10 yr., fluctuated between 162 and 133′. After 4 yr. friction loss in No. 2 approached that in No. 1. Seven yr. after start length of piping some 6,000′ from pumphouse opened for inspection. Pipe coated with black deposit ranging from $\frac{1}{8}$″ thickness at top to paper thickness at bottom. Underneath coating, concrete in excellent condition.—*H. E. Babbitt.*

WATER TANKS

Water Tanks Fabricated by Shielded-Arc Process. ANON. New Zealand Eng., p. 608 (June 10, '47). Illustrated description of 2 new elevated water tanks built of metal plates in all-welded design, streamlined and very neat in appearance. No out-

(Continued on page 54)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(Continued from page 52)

side ladders, access to outside and inside being by rungs welded inside one of sloping columns under tanks and vertical cylinder, or "access tube," extending from top of this column through water in tank to roof manhole. Cylindrical sections, as large as possible with regard to transport, weld-fabricated as shop jobs, and column splices and complete tank units erected by elec.-arc methods on site. Larger tank, 250,000-gal. capac., 40′ in diam. with water depth of 31′5″; 4 supporting columns, each 4½′ in diam., and central riser 4′ in diam.; shell of tank ¼″–1″ thick. All plate sections rolled, roof and bottom plates being pressed to shape by dishing machine. Diagram shows cross section of welded joints and section of welding constr. through balcony.—*Ed.*

Construction of Elevated Tanks. A. J. Van Walraven. Water (Neth.) **31**:238:248 (Nov. 27 & Dec. 11 '47). Under present conditions in Holland reinforced-concrete elevated tanks must be constructed so that forms used are simple and work can be done mostly by unskilled labor. Mixts. used 1:2:3, using about 300 kg. cement per cu.m. concrete. Tanks must be coated on inside, constr. must be such that microscopic cracks prevented or kept to min., and concrete mixt. must be self-closing. Tanks constructed with 1 single wooden concrete form and with sliding forms discussed and illustrated in detail.—*W. Rudolfs.*

Reinforced-Concrete Water Tanks on Ground Subject to Settlement. L. E. Hunter. Civ. Eng. (Gt. Br.) **42**:481 (Nov. '47). When necessary to build tank on ground that may settle considerably after constr., not practicable to use piling. Analogy to subsidence of ground is ship at sea. Only way ship can be made sufficiently strong is

(Continued on page 56)

(*Continued from page 54*)

to introduce stiffness in frame. Tank must be completely self-supporting when any portion of ground falls away. Well constructed tank should be able to tilt 10–15 deg. without cracking. Most economical layout is to arrange tank so that 20–25% of width cantilevers over each end. For tanks up to 50–60′ in external diam. or length, possible to adopt suitable design without internal cross walls. Usual max. subsidence conditions are: [1] no settlement over base area, tank base designed on cantilever effect due to water pressure and resultant upward bearing pressure; [2] symmetrical, rectilinear settlement at both ends of base; [3] symmetrical, rectilinear settlement in middle of base; [4] unsymmetrical, rectilinear settlement at one end of base; [5] unsymmetrical, diagonal settlement at one end of base. Bearing pressure diagrams can be turned completely around as settlement can occur on any side of tank base. Shear reinforcement should be plentiful.—*H. E. Babbitt.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below according to their subject matter.

Supply and Treatment

Frequency of Minor Floods. HAROLD A. THOMAS JR. J. Boston Soc. Civ. Engrs., **35**:4:425 (Oct. '48).

Electronic Device Speeds Flood Forecasting. R. LINSLEY, L. FOSKETT & M. KOHLER. Eng. News-Rec., **141**:26:64 (Dec. 23, '48).

Estimating Ground Water Supplies. B. A. BARNES. Eng. News-Rec., **141**:26:72 (Dec. 23, '48).

Soil Conservation—Its Municipal Meaning. H. N. SMITH. Am. City, **64**:1:71 (Jan. '49).

(*Continued on page 58*)

(*Continued from page 56*)

Geologic Correlation and Hydrologic Interpretation of Water Analyses. T. E. LARSON. Wtr. & Sew. Wks., **96**:2:67 (Feb. '49).

Schistosomiasis Control—An Engineering Problem. E. J. HERRINGER. Pub. Wks., **80**:1:36 (Jan. '49).

Removal of Tastes and Odors From Water Supplies by Active Carbon. DAVID C. COLEBAUGH JR. & JOHN W. HASSLER. Taste & Odor Control J., **15**:1:1 (Jan. '49).

Water Well Acidizing. BRADFORD J. COTEY. Southwest W.W. J., **30**:10:6 (Jan. '49).

Industrial Water on the Gulf Coast. WILL H. SHEARON JR. Chem. & Eng. News, **27**:4:220 (Jan. 24, '49).

Making a Waste Survey for a Large Industry. W. J. ELDRIDGE. Wtr. & Sew. Wks., **96**:2:55 (Feb. '49).

Engineering and Technology

Rapid Analytical Techniques for Water and Sewage. G. W. REID & R. S. INGOLS. Pub. Wks., **80**:1:27 (Jan. '49).

Data on Flow Tests on Mokelumne Aqueduct. EDWIN B. COBB. J. Boston Soc. Civ. Engrs., **35**:4:509 (Oct. '48).

Integrating the Equation of Nonuniform Flow. M. E. VON SEGGERN. Proc. A.S.C.E., **75**:1:105 (Jan. '49)

No Mystery in Weir Flow Calculations. F. T. MAVIS. Eng. News-Rec., **142**:1:76 (Jan. 6, '94).

Formula for Velocity at Beginning of Bed Load Movement Is Reappraised. F. T. MAVIS & L. M. LAUSHEY. Civ. Eng., **19**:1:38 (Jan. '49).

Review of Slope Protection Methods —Discussion. WALTER F. EMMONS & ADOLF A. MEYER. Proc. A.S.C.E., **75**:1:155 (Jan. '49).

Building a Trio of Earthfill Dams. ANON. Eng. News-Rec., **142**:1:60 (Jan. 6, '49).

Hydraulic Ram Cuts Water Pumping Costs. ANON. Am. City, **64**:1:106 (Jan. '49).

Maintenance and Repair

Maintenance and Repair of Gate and Globe Valves. R. A. HENDRICKSON. Am. City, **64**:1:96 (Jan. '49).

Experience at Bagnell Dam to Prevent Corrosion of Underwater Steel and Iron. TURNER WHITE JR. Corr., **5**:1:25 (Jan. '49).

Corrosion Problems in Water Wells. T. E. LARSON. Corr., **5**:1:27 (Jan. '49).

A Pipe Thawer With Year-round Usefulness. F. J. PURDY. J. N.H. W.W. Assn., **10**:1:5 (Dec. '48).

Pipe Thawing Experiences. JAMES A. SWEENEY. J.N.H.W.W. Assn., **10**:1:11 (Dec. '48).

Lining 62" and 36" Pipe Returns 13% on Cost. JOHN B. DEAN. Pub. Wks., **80**:1:20 (Jan. '49).

Service Lines

A simplified, concise manual on ferric chloride has been prepared for distribution by Pennsylvania Salt Mfg. Co., 1000 Widener Bldg., Philadelphia 7, Pa. Entitled "Anhydrous Ferric Chloride," the booklet treats of the properties, uses and methods of handling of the chemical in both the anhydrous form, of which Pennsalt is sole producer, and liquid solution form.

Water meter yokes in copper and iron, swivel nut meter couplings, angle meter stops and meter box covers are depicted in Mueller catalog H–12, which covers the company's complete line of meter setting equipment. As such, the 28-page booklet includes the material previously listed in Catalog H. Address Mueller Co., Decatur 70, Ill.

The "Usefulness and Limitations of Samples" is the subject of a symposium held under American Society for Testing Materials auspices, and available in a 40-page reprint from the society, at 1916 Race St., Philadelphia 3, Pa., at $1 per copy. The papers included in the publication discuss the uncertainties of sampling, the relation of the amount of inspection to the control of quality effected, and the variations in materials, testing and sample sizes.

Swimming pool accessories produced by Everson Mfg. Corp., 214 W. Huron St., Chicago 10, are described in a bulletin, No. 3000–A, available from the company. Suction cleaners, overflow drains, Sterelators and other purification equipment are included.

(*Continued on page 64*)

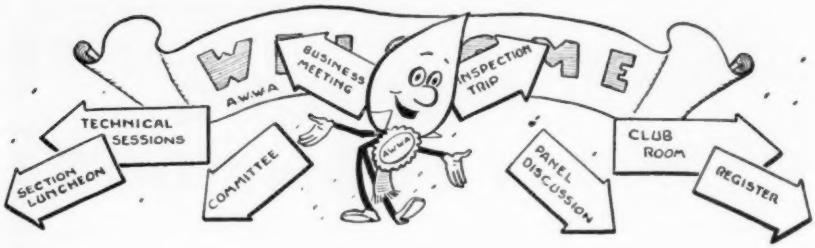
(Continued from page 62)

Rex sanitation and process equipment produced by the Chain Belt Co., 1600 W. Bruce St., Milwaukee 4, Wis., is described and illustrated in a 36-page bulletin, No. 48–41, available on request. Grit chambers, grit washers, conveyor sludge collectors, traveling water screen and flash mixers are among the equipment discussed.

An article on "Pure Water by Ion Exchange" by Russell N. Dwyer is featured in the current issue of the *Announcer of Scientific Equipment.* The article discusses the history of production of mineral-free water for laboratory use, from distillation in antiquity through contemporary methods of deionization. Available on request from Eberbach & Son Co., Ann Arbor, Mich.

"Gate Valve Operation" is the subject of a 12-page bulletin issued by Payne Dean & Co., Madison, Conn. Included are descriptions and illustrative material on truck-mounted operators for closing gates against unbalanced flow and other heavy duty service, on small portable power trucks, and on power wrenches.

A 100-page manual intended to help engineers design both multiple and light duty V-belt drives has been released by the mechanical goods division, U.S. Rubber Co., Rockefeller Center, New York 20, N.Y.



Section Meeting Reports

Southeastern Section: The twentieth annual meeting of the Southeastern Section was held at the Sheraton Bon Air Hotel, Augusta, Ga., on December 6, 7 and 8, 1948, with a total registration of 154, including water works men, manufacturers' representatives and guests.

After an opening prayer by the Rev. W. M. Lee, a cordial welcome was extended to those present by Ernest Pund of Augusta. Following the response by Chairman W. R. Wise, the technical program got under way with a most stimulating discussion of the recent advances in water treatment by A. P. Black, A.W.W.A. Vice-President.

Laurence G. Leach, Hydraulics Engr. with the Army Corps of Engineers, discussed the possibility of supplementing water supplies by virtue of the Army Engineer's program of water impoundment throughout the South Atlantic states and explained the work now in progress at the Clark Hill development on the Savannah River near Augusta. This added greatly to the understanding and appreciation of all the registrants who visited the Clark Hill project site during the afternoon of the first day of the meeting. This tour was planned by the city of Augusta in cooperation with the U.S. Army Engineers and was a thoroughly enjoyable part of the Southeastern Section's program.

Following the visit to Clark Hill, everyone was invited to attend a barbecue as guests of the city of Augusta. After the meal, the crowd was entertained by a local magician, an employee of the Augusta Water Works.

On Tuesday morning, December 7, W. R. Wise discussed modern methods of adjusting rates with specific references to the part a good public relations program could play in preparing for a change. He emphasized the importance of informing customers why an adjustment is necessary and what it is designed to accomplish. This paper was well received and a lively discussion from the floor followed its presentation.

J. L. Hawkins discussed the many problems involved in financing water service beyond the city limits and suggested that no hard and fast rule could be universally applied but rather that a solution should be worked

(Continued on page 68)

(*Continued from page 66*)

out which would consider local necessities, laws which might be regulatory, and a good neighbor policy. Participation from the floor in the discussion, led by Henry M. Mathews, was excellent, and many valuable experiences encountered in the field were brought out.

Frederick L. Bird of Dun and Bradstreet, New York City, offered a highly informative discussion of the financing of water system development (*see* p. 105, Feb. issue). This most excellent paper, though presenting a definite challenge, was an outstanding contribution to the success of the meeting. In the discussion that followed, R. B. Simms presented pertinent information about his experiences at his water plant at Spartanburg, S.C. George H. Sparks of East Point, Ga., described some of the difficulties his city had experienced in the sale of bonds which were issued to provide needed improvements.

Homer E. Beckwith's paper on water wastes brought out the necessity of locating and repairing points within the water system where wastes might occur. He enumerated the many possible sources of water waste and explained how best to correct the imperfections causing this waste. Thomas C. Earl of Savannah, Ga., discussed this paper and participation from the floor indicated special interest in this all-important subject.

Lewis L. Barnes delivered a most interesting paper on the problems air conditioning equipment might cause in the water distribution system. His paper was discussed by Frank W. Chapman, who explained the problems he had encountered at Greenwood, S.C., with air conditioning equipment and explained what had been done to solve these problems. J. W. Morris and O. G. Carpenter of the National Board of Fire Underwriters explained the standards by which a water system was evaluated and explained further how this evaluation could be utilized in planning for improvements to a water system. F. B. McDowell discussed what Charleston, S.C., had done and is doing to meet the requirements of the fire underwriters. Further discussion by Roy Ruggles and Paul Weir of Atlanta, Ga., brought out the benefits derived from evaluation surveys by the fire underwriters.

Wednesday morning's technical program was opened with a paper by Charles H. Starling, who discussed improved methods of coagulation. His paper was discussed by H. Grady Wylds of Augusta, and the discussion from the floor on this subject was so lively that the chairman had to call time in order to proceed with the remainder of the program.

A. T. Storey of the Atlanta water works delivered a paper on the mechanics of distribution system sampling in which he emphasized the necessity of a comprehensive system sampling program and explained how such a program could be planned to serve a definite need in the development and establishment of good public relations. Alan M. Johnstone of Orangeburg, S.C., compared the sampling methods employed in several cities

(*Continued on page 70*)

(*Continued from page 68*)

within the Southeastern Section. A majority of the cities included in the comparison collected system samples but apparently no uniformity existed in the evaluation of the results.

F. E. DeMartini of the U.S. Public Health Service delivered a paper entitled "Stream Pollution Control Is Here," in which he set forth the organization of authority and responsibility under the terms of Public Law 845, passed by the 80th Congress. His remarks were most applicable to the problems of water supply and were of outstanding interest to everyone present. The discussion by Gilbert Frith and T. A. Kolb of this paper enumerated and emphasized many of the perplexing problems connected with stream pollution control.

The social activity of the meeting included, for the first time in this Section, a luncheon honoring the 25-year members of the Association. Two men were honored by the Section on the occasion—C. W. Smedberg of Atlanta and R. B. Simms of Spartanburg, S.C. M. F. Tiernan, President of Wallace & Tiernan Co., made an inspiring and entertaining talk on the occasion of this luncheon. The function was a specific contribution to the fellowship enjoyed at the meeting of this Section.

The annual banquet was held on Tuesday night, December 7, and was thoroughly enjoyed by the 154 persons attending. The usual festive air prevailed, with attendant songs and other outstanding evidences of good fellowship among the members present. W. R. Wise, Chairman of the Section, as Master of Ceremonies, presented Harry Jordan, National Secretary, who spoke on the subject "The Water Works Profession Comes of Age." Francis Buck McDowell, Engineer-Manager of the Charleston, S.C., water works, was nominated to receive the George W. Fuller Award, because of the outstanding contributions to the water works profession through his engineering skill and boldness, demonstrated in his many experiences and activities.

A registration of 154 persons at the meeting—three more than the Section enrollment—definitely established the fact that the twentieth annual meeting of this Section was an outstanding success.

W. T. Linton
Secretary-Treasurer

Cuban Section: The annual meeting of the Cuban Section—probably one of its most successful events—was held in Havana on December 2–4, 1948. A record attendance and registration was noted. Every member of the Section attended, with the exception of two who were out of the country on trips.

Chairman García Montes began by introducing Nicolás Castellanos, Mayor of Havana, who welcomed the visitors to the Convention, and gave

(*Continued on page 72*)

(*Continued from page 70*)

the keys of the city to those attending. Vice-President A. P. Black, on behalf of the national Association, gave an inspiring talk on the benefits to be derived from membership in the A.W.W.A.

Following this address, the first paper was presented by Abel Fernández and Ernesto Trelles in collaboration. An exceedingly interesting documentary film on the history of the Havana water works, as well as the work now being accomplished, was exhibited. In the afternoon two very instructive papers were presented by Valdés Roig and Luis Alberto Núñez, and met with great applause.

That evening a party was given by Secretary Larry Daniel at the Havana Yacht Club to all the foreign visitors, and conviviality was the order of the day.

On Friday morning, the meeting was called to order by Chairman García Montes, who turned the gavel over to Vice-President Black, and three very fine papers were read. The discussion following the papers indicated that they had been enjoyed by all.

A brief business meeting was followed by refreshments, and after that, naturally, there could be no other serious business transacted. At the lunch given at the Zaragozana, the kind and number of toasts rendered

(*Continued on page 74*)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(*Continued from page 72*)

made our American visitors declare Havana a yearly "must" on their program.

On Saturday morning a trip to the interior of the island was made. This trip included a stop at the new Pontusco plant, which manufactures concrete pipe. A special exhibition was held, and a splendid reception accorded the officers of the Section, visitors and members. A "Café de Honor" was offered, and liquid refreshment was the order of the day.

The tour continued merrily to Matanzas, where the visitors were greeted by the officers of the Matanzas Aqueduct, under the able direction of T. M. Victory, Chief Engineer of the Cia. Cubana de Electricidad and Past Chairman of the Cuban Section. A splendid *arroz con pollo* (chicken with rice) was offered and again there was a feeling of fraternity and good will.

Everyone enjoyed the meeting so thoroughly that already plans are being made for 1949, and the Cuban Section promises a highly instructive as well as entertaining time to all of our good neighbors from the North that care to come down to this tropical Paradise, which, as Christopher Columbus stated, is "the most beautiful land ever gazed upon by human eyes."

LAURENCE H. DANIEL
Secretary-Treasurer

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American Cast Iron Pipe Co. 39
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American Well Works 3
Anthracite Equipment Corp. .... —
Armco Drainage & Metal Products, Inc. 65
Atlas Mineral Products Co., The .... —
Badger Meter Mfg. Co. 77
Belco Industrial Equipment Div., Inc. .... —
Buffalo Meter Co. .... —
Builders-Providence, Inc. 23
Calgon, Inc. .... —
Carson-Cadillac Co. 40
Cast Iron Pipe Research Assn., The 60–61
Central Foundry Co., The 10
Centriline Corp. 5
Chain Belt Co. .... —
Chicago Bridge & Iron Co. 71
Clow, James B., & Sons .... —
Dearborn Chemical Co. 83
De Laval Steam Turbine Co. 81
Difco Laboratories 72
Dorr Co., The .... —
Dowell Incorporated ix
Dresser Mfg. Div. .... —
Economy Pumps, Inc. 74
Eddy Valve Co. .... —
Electric Fish Screen Co. 62
Electro Rust-Proofing Corp. 32
Ellis & Ford Mfg. Co. 12
Everson Mfg. Corp. 16
Fairbanks, Morse & Co. .... —
Flexible Sewer-Rod Equipment Co. 43
Ford Meter Box Co., The 7
Fraser Utility Supply Co. .... —
General Chemical Div., Allied Chemical & Dye Corp. 46–47
Glauber Brass Mfg. Co., The .... —
Greenberg's, M., Sons 50
Michael Hayman & Co., Inc. .... —
Havs Mfg. Co. 41
Hellige, Inc. 64
Hersey Mfg. Co. 33
Hydraulic Development Corp. 69
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co. x
Inertol Co., Inc. .... —
Infilco, Inc. 13
Iowa Valve Co. .... —
Johns-Manville Corp. .... vi–vii
Jones, J. W., Co. .... —
James Jones Co. 53
Keasbey & Mattison Co. 15
Kennedy Valve Mfg. Co., The 35
Klett Mfg. Co. 36
Koppers Co., Inc. 49
Kupferle, John C., Foundry Co. 10
LaMotte Chemical Products Co. 34
Layne & Bowler, Inc. 31
Leadite Co., The .... Cover 4
Lee Hydraulic Co. 16
Lock Joint Pipe Co. i
M & H Valve & Fittings Co. 40
Mabbs Hydraulic Packing Co. .... —
Mathieson Chemical Corp. .... —
Mueller Co. .... —
National Cast Iron Pipe .... —
National Water Main Cleaning Co. 11
Neptune Meter Co. iii
Northern Gravel Co. 64
Northrop & Co., Inc. 14
Omega Machine Co. (Div., Builders Iron Fdry.) 19
Peerless Pump Div. .... —
Permutit Co. 55
Phelps Dodge Refining Corp. 42
Philadelphia Gear Works, Inc. 6
Pittsburgh-Des Moines Steel Co. .... —
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.) 84
Pollard, Jos. G., Co., Inc. 56
Preload Companies, The 79
Proportioneers, Inc. 75
Reilly Tar & Chemical Co. .... Cover 3
Rensselaer Valve Co. 17
Roberts Filter Mfg. Co. 29
Ross Valve Mfg. Co. 21
Simplex Valve & Meter Co. 45
Smith, A. P., Mfg. Co., The 63
Solvay Sales Div., Allied Chemical & Dye Corp. .... —
Sparling, R. W. 51
Standard Pipeprotection, Inc. .... —
Stuart Corp. 44
Syntron Co. .... —
Tagco, Inc. 12
Tate Pipe Lines, Inc. .... —
Tennessee Corp. .... —
U. S. Pipe & Foundry Co. v
Virginia Smelting Co. 59
Walker Process Equipment, Inc. .... —
Wallace & Tiernan Co., Inc. xii
Warren Foundry & Pipe Co. 73
Well Machinery & Supply Co. 67
Welsbach Corp., Ozone Processes Div. 9
Wood, R. D., Co. .... Cover 2
Worthington-Gamon Meter Co. 57
Zeolite Chemical Co. 20

Directory of Professional Services—pp. 24–27

Albright & Friel, Inc.
Alvord, Burdick & Howson
Behrman, A. S.
Black & Veatch
Clinton L. Bogert Assoc.
Bowe, Albertson & Assoc.
Buck, Seifert and Jost
Burgess & Niple
Burns & McDonnell Eng. Co.
Caird, James M.
Camp, Dresser & McKee
Chester, Engineers, The
Consoer, Townsend & Assoc.
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Gannett Fleming Corddry & Carpenter, Inc.
Glace, Ivan M.
Greeley & Hansen
Havens & Emerson
Haydock, Charles
Hitchcock & Estabrook, Inc.
Hunt, Robert W., Co.
Jones, Henry & Schoonmaker
Knowles, Morris, Inc.
Leggette, R. M.
Roberto Meneses Hoyos & Co.
Metcalf & Eddy
Nutting, H. C., Co.
Parsons, Brinckerhoff, Hall & Macdonald
Malcolm Pirnie Engineers
Pitometer Co.
Purcell, Lee T.
Ripple & Howe
Rose, Nicholas A.
Russell & Axon
Sanborn, James F.
Sirrine, J. E., Co.
Stanley Eng. Co.
Stilson, Alden E. & Assoc.
Ward & Strand
Weston & Sampson
Whitman & Howard
Whitman, Requardt & Assoc.

Index of Advertisers' Products

Acidizing of Water Wells:
Dowell Incorporated

Activated Carbon:
Industrial Chemical Sales Div.

Aerators (Air Diffusers):
American Well Works
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Walker Process Equipment, Inc.

Air Compressors:
DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.

Air-Lift Pumping Systems:
Worthington Pump & Mach. Corp.

Alum (Sulfate of Alumina):
American Cyanamid Co., Industrial Chemicals Div.
General Chemical Div.
Stuart Corp.

Ammonia, Anhydrous:
General Chemical Div.
Mathieson Chemical Corp.

Ammonia Receivers:
Worthington Pump & Mach. Corp.

Ammoniators:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Brass Goods:
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M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.

Calcium Hypochlorite:
Mathieson Chemical Corp.

Carbon Dioxide Generators:
Infilco, Inc.
Walker Process Equipment, Inc.

Cement Mortar Lining:
Centriline Corp.
Tate Pipe Linings, Inc.

Chemical Cleaning of Water Mains:
Dowell Incorporated

Chemical Feed Apparatus:
Belco Industrial Equipment Div., Inc.
Builders-Providence, Inc.
Everson Mfg. Corp.
Infilco, Inc.
Liquid Conditioning Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.
Proportioneers, Inc.
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Syntron Co.
Wallace & Tiernan Co., Inc.

Chemical Scale Removal Services:
Dowell Incorporated

Chemists and Engineers:
(See Prof. Services, pp. 24–27)

Chlorination Equipment:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine Comparators:
Everson Mfg. Corp.
Hellige, Inc.
Klett Mfg. Co.
LaMotte Chemical Products Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine, Liquid:
J. W. Jones Co.
Mathieson Chemical Corp.
Solvay Sales Div.
Wallace & Tiernan Co., Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
James Jones Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Stauffer Mfg. Co.
Warren Foundry & Pipe Corp.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.
Smith-Blair, Inc.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
Smith-Blair, Inc.
Stauffer Mfg. Co.
Warren Foundry & Pipe Corp.

Clarifiers:
American Well Works
Chain Belt Co.
Dorr Co.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Walker Process Equipment, Inc.

Cleaning Water Mains:
Flexible Underground Pipe Cleaning Co.
National Water Main Cleaning Co.

Cocks, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Compressors, Portable:
Worthington Pump & Mach. Corp.

Condensers:
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Tennessee Corp.

Corrosion Control:
Calgon, Inc.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Fairbanks, Morse & Co.
Philadelphia Gear Works, Inc.

Culture Media:
Difco Laboratories, Inc.

Dechlorinating Agent:
Virginia Smelting Co.

Diaphragms, Pump:
Dorr Co.
Proportioneers, Inc.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Directory of Experts, pp. 24–27)

Feed Water Treatment:
Calgon, Inc.
Dearborn Chemical Co.
Infilco, Inc.
Liquid Conditioning Corp.

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Infilco, Inc.
Northern Gravel Co.

Filters, Incl. Feed Water:
Belco Industrial Equipment Div., Inc.
Dorr Co.
Everson Mfg. Corp.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.
Walker Process Equipment, Inc.

Filtration Plant Equipment:
Builders-Providence, Inc.
Chain Belt Co.
Difco Laboratories, Inc.
Infilco, Inc.
Liquid Conditioning Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Finders, Pipe:
Jos. G. Pollard Co., Inc.

Fish Screens:
Electric Fish Screen Co.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Smith-Blair, Inc.

Fittings, Tees, Ells, etc.:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Smith-Blair, Inc.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

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Dorr Co.
Infilco, Inc.

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Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Furnaces, Joint Compound:
Northrop & Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.

Gages, Loss of Head, Rate of Flow, Sand Expansion:
Builders-Providence, Inc.
Infilco, Inc.
Northrop & Co., Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Gasholders:
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Northrop & Co., Inc.

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R. D. Wood Co.

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Philadelphia Gear Works, Inc.

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A. P. Smith Mfg. Co.

Greensand (Zeolite):
(See Zeolite)

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M. Greenberg's Sons
James Jones Co.
Kennedy Valve Mfg. Co.
John C. Kupferle Foundry Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
Ross Valve Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Hellige, Inc.
LaMotte Chemical Products Co.
Wallace & Tiernan Co., Inc.

Iron Removal Plants:
American Well Works
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Michael Hayman & Co., Inc.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Dresser Mfg. Div.
Smith-Blair, Inc.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Lime Slakers and Feeders:
Dorr Co.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)

Manometers, Rate of Flow:
Builders-Providence, Inc.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.
Buffalo Meter Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meter Washers:
Mabbs Hydraulic Packing Co.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.

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Welsbach Corp., Ozone Processes Div.

Packing, Rawhide:
Mabbs Hydraulic Packing Co.

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Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Preload Companies, The
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Dearborn Chemical Co.
Koppers Co., Inc.
Preload Companies, The
Reilly Tar & Chemical Co.
Standard Pipeprotection, Inc.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe, Steel:
Armco Drainage & Metal Products, Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Everson Mfg. Corp.
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc

Pumps, Deep Well:
American Well Works
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Proportioneers, Inc.

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Pumps, Hydraulic Booster:
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Ross Valve Mfg. Co.

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Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Recorders, Gas Density CO_2, NH_3, SO_2, etc.:
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Dearborn Chemical Co.
Electro Rust-Proofing Corp.

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(See Gages)

Sand, Filtration:
(See Filtration Sand)

Sleeves:
(See Clamps)

Sleeves and Valves, Tapping:
James B. Clow & Sons
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Liquid Conditioning Corp.
Permutit Co.

Soda Ash:
Mathieson Chemical Corp.
Solvay Sales Div.

Sodium Hexametaphosphate:
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div., Inc.
Dearborn Chemical Co.
Dorr Co.
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Liquid Conditioning Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

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Permutit Co.
Tennessee Corp.
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Chicago Bridge & Iron Co.
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Pittsburgh-Des Moines Steel Co.

Storage Tanks:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Sulfur Dioxide, Liquid:
Virginia Smelting Co.

Surface Wash Equipment:
Liquid Conditioning Corp.
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Belco Industrial Equipment Div., Inc.
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Chicago Bridge & Iron Co.
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Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Industriai Chemical Sales Div.
Infilco, Inc.
Liquid Conditioning Corp.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
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Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

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Ford Meter Box Co.
Rensselaer Valve Co.
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R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
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Kennedy Valve Mfg. Co.
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Ross Valve Mfg. Co., Inc.

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James Jones Co.
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Valves, Hydraulically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
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Valves, Swing Check:
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M. Greenberg's Sons
Rensselaer Valve Co.
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Vibrators (Chemical Feeding):
Syntron Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants:
(See Softeners)

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
LaMotte Chemical Products Co.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Infilco, Inc.
Liquid Conditioning Corp.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

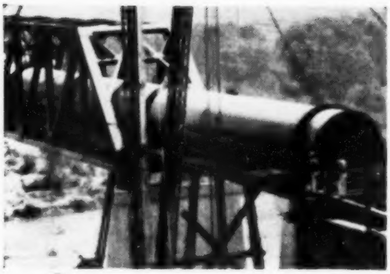
Well Acidizing:
Dowell Incorporated

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite:
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Zeolite Chemical Co.

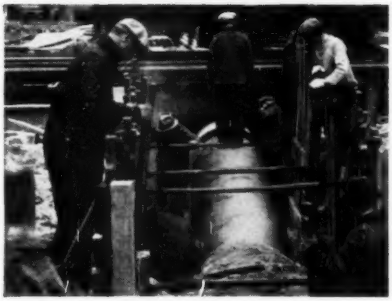
A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.



Above Ground

Corrosion insurance

Under Ground



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Above ground or under ground—whether exposed to the searing desert sun or buried in the cold, damp soil beneath city streets, Reilly Enamel provides water lines with dependable, lasting protection against corrosion.

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